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GEOPHYSICS

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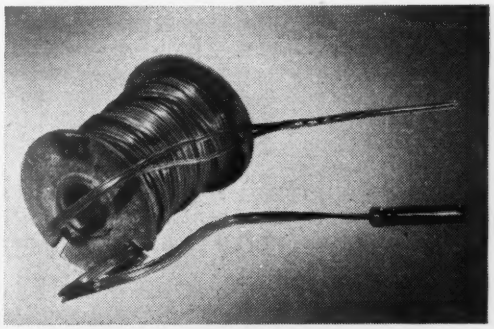

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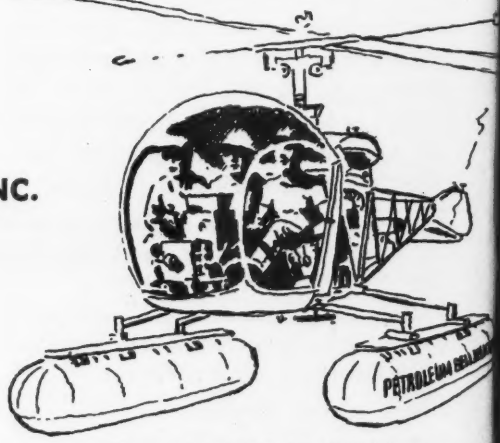

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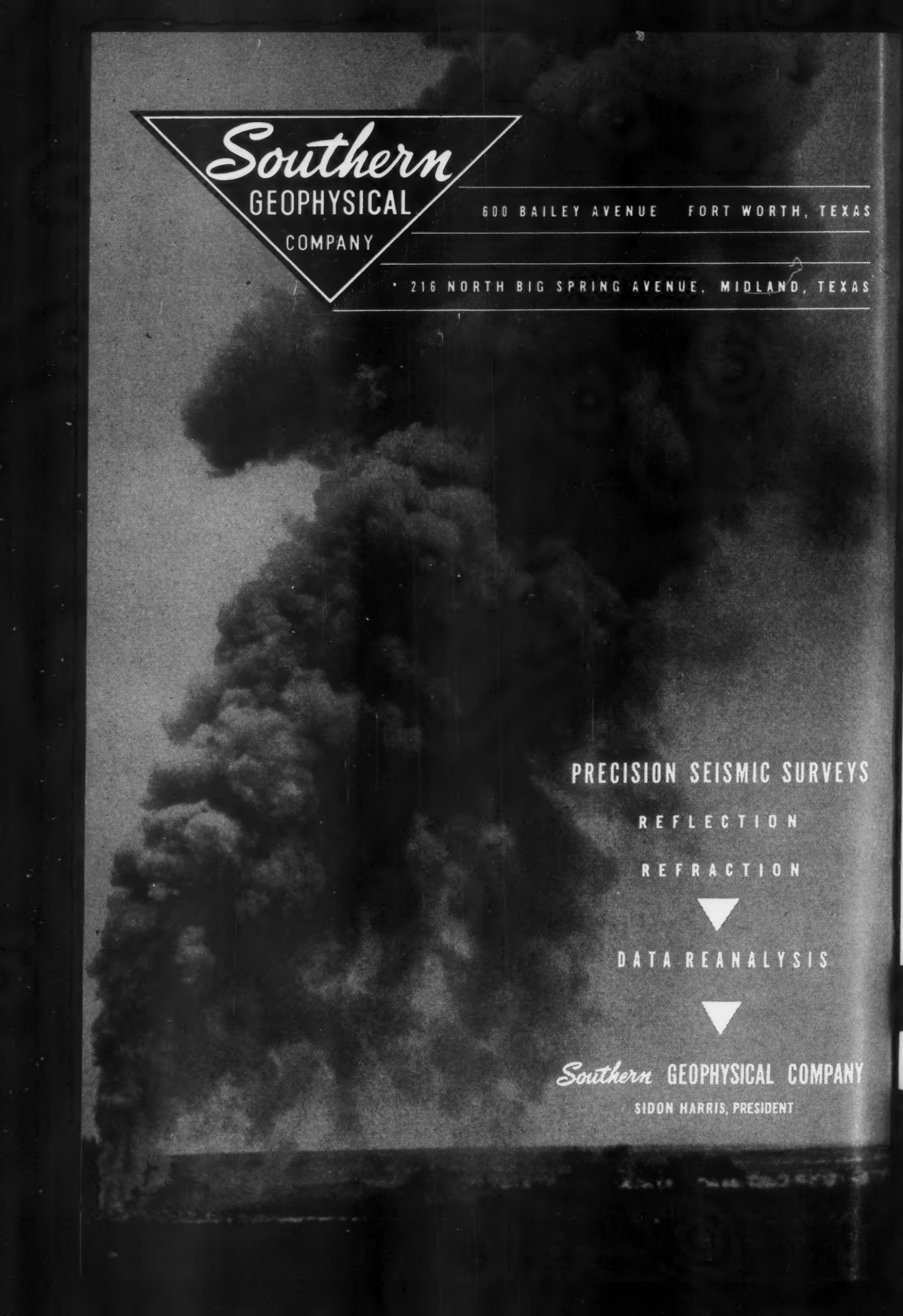
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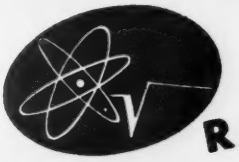

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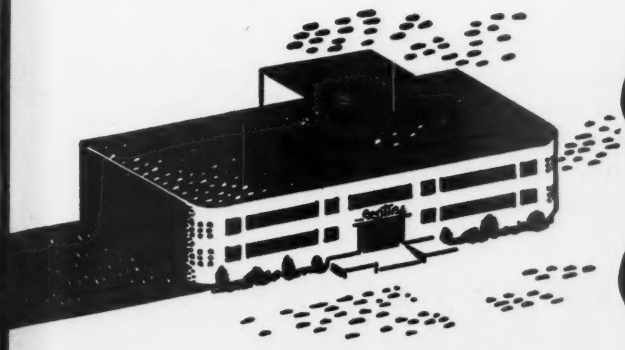

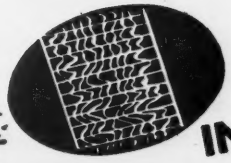

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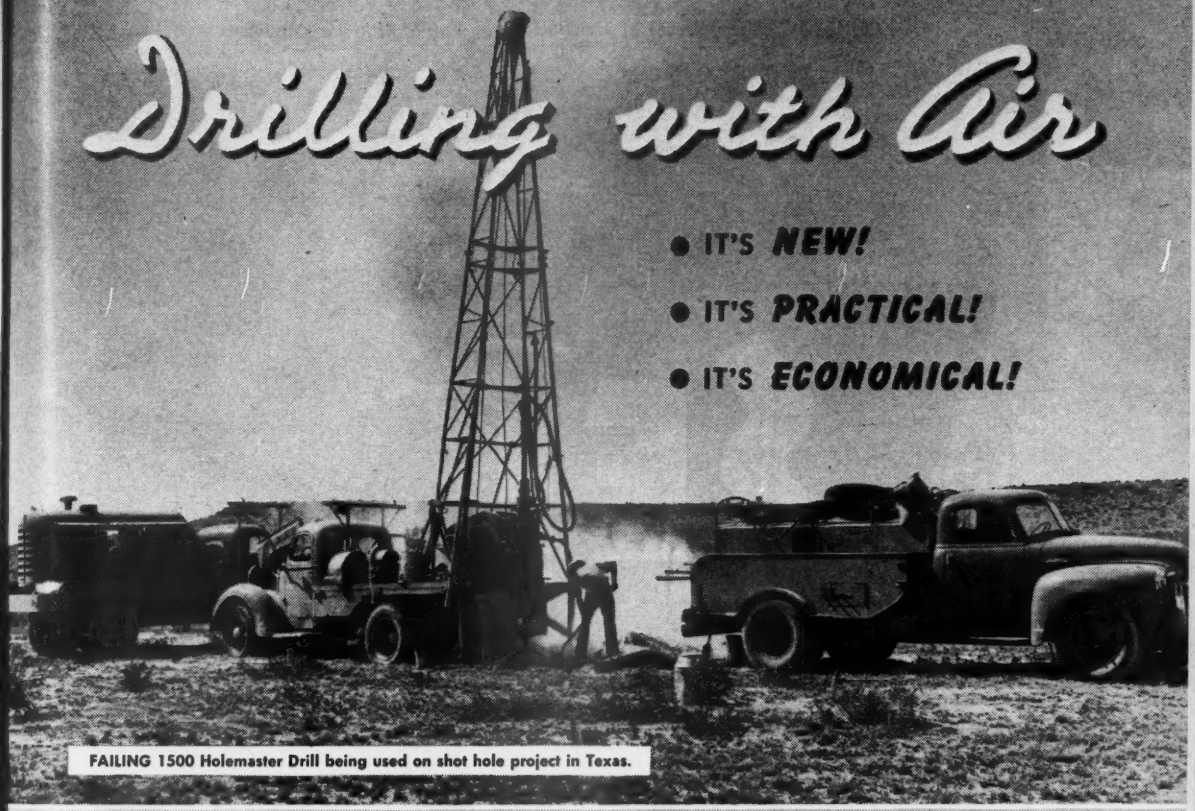

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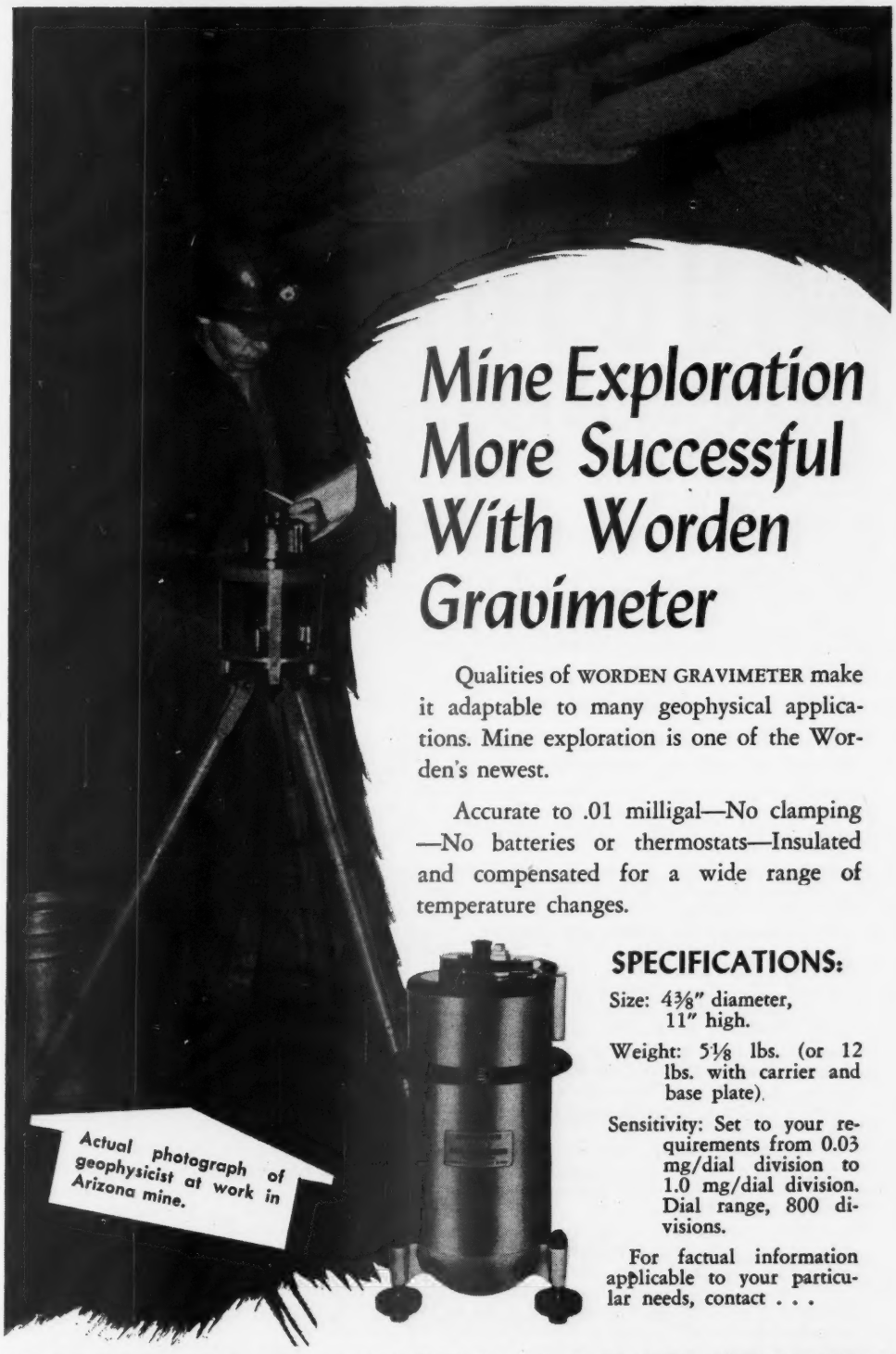

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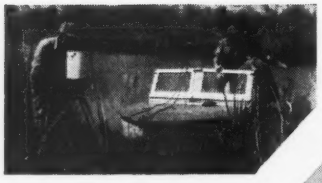

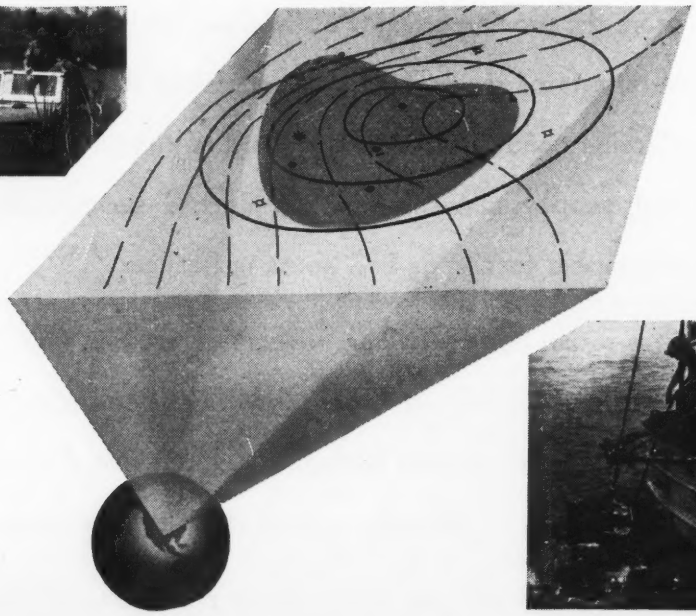

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GEOPHYSICAL HISTORY OF THE DELHI FIELD, RICHLAND, FRANKLIN, AND MADISON PARISHES, LOUISIANA*

W. E. HOLLINGSWORTH†

ABSTRACT

The geophysical history of the Delhi Field started in 1938 when a Gulf gravity crew entered the area. In early 1940 results of drilling to the east indicated the absence of Tuscaloosa beds and a possible pinchout. In 1944, a seismograph crew under contract to Sun Oil Company and C. H. Murphy entered the area. A small closure was found and drilled. Production was established in 1944 from Paluxy beds.

The geophysical history of the Delhi Field started in the early part of 1938 when a Gulf gravity crew under Carl L. Bryan conducted a reconnaissance survey of the area. This work indicated a definite gravity minimum in the area and Gulf leased some acreage on this anomaly in the latter part of 1938. Additional gravity stations for more detail were run in 1942 by another Gulf gravity crew under R. J. Copeland. The observed gravity data of these combined surveys is shown ln Figure 1. As can be seen from this contour map, a gravity minimum exists in the southeast portion of T 17N-R 9E and approximately 3 miles southwest of the town of Delhi, Louisiana.

Figure 2 shows the results of eliminating the gravity regional from the observed picture. The assumed regional is shown as the lighter lines, while the heavier lines show the residual anomaly of about 2 milligals. This residual feature is shifted slightly to the west and lies in the southwest portion of T 17N-R 9E. The location of the discovery well is in the northeast portion of this anomaly. The approximate outline of the field as it now exists is seen to run directly across this anomaly. The presence of this gravity feature was unknown, of course, to the Sun Oil Company. Their interest in the area arose from geologic data in three wells which were drilled to the east of the town of Delhi.

In early 1940, the Gulf Sondheimer #1 dry hole was drilled in Section 33, T 18N-R 12E approximately 12 miles northeast of the town of Delhi. This well

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† Sun Oil Company, Beaumont, Texas.

was drilled into lower Cretaceous beds with the Tuscaloosa section being absent. Following this dry hole the C. H. Murphy interests started a seismograph survey east and southeast of the Gulf Sondheimer well. This survey indicated a possible salt dome in Section 34, T 17N-R 13E, and in 1942 the Murphy-Mahoney No. 1

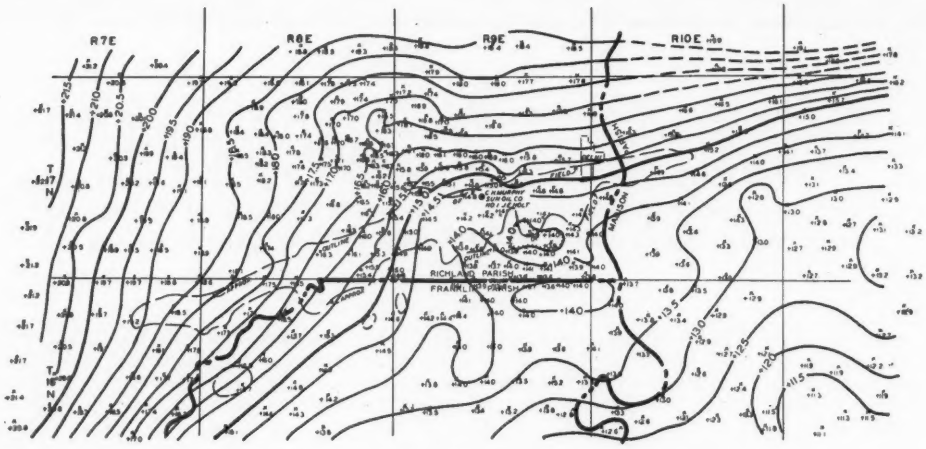

FIG. 1. Map showing observed gravity data.

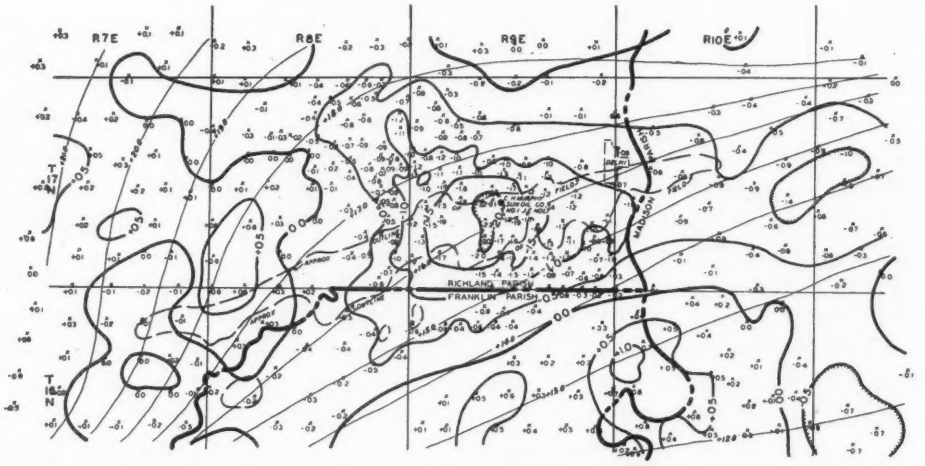

FIG. 2. Map showing residual gravity after elimination of regional gravity.

well was drilled. This well was dry and abandoned, but did encounter some 800 feet of Tuscaloosa section which was missing in the Gulf Sondheimer well to the northwest. The presence of Tuscaloosa beds in the Mahoney well and the absence of these same beds in the Gulf Sondheimer as determined by paleontological and lithologic studies indicated that the truncation of beds occurred somewhere between the two wells.

This postulated truncation of Tuscaloosa beds through this area was noted by the Sun Oil Company geologists in Dallas, Mr. A. M. Lloyd being particularly insistent upon following it up, and the Sun Oil Company took checkerboard leases across this area. The Murphy Sondheimer No. 1 was then located in Section 10, T 17N-R 12E with the support of Sun Oil Company. It drilled into lower Cretaceous beds after encountering approximately 300 feet of Tuscaloosa section, being dry and abandoned early in 1944. Following this dry hole a joint operation was

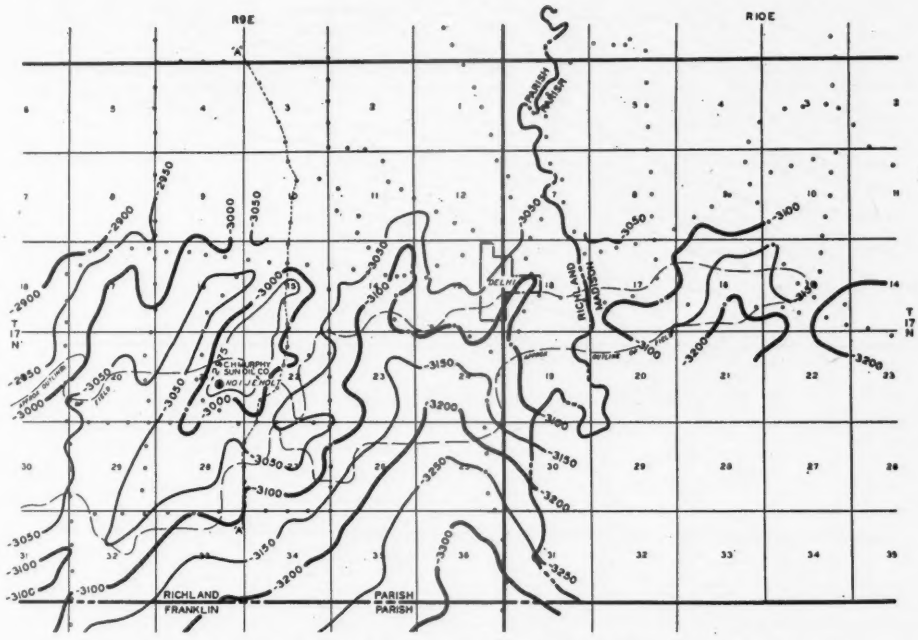

FIG. 3. Map showing seismograph contours on Selma Chalk.

formed between C. H. Murphy Interests and Sun Oil Company and lease holdings were taken along this postulated Tuscaloosa truncation to the west and southwest. Some acreage was acquired in what is now the Delhi Field.

In May 1944, a Petty Geophysical crew under Carl Hemmi was sent in to cover T 17N-R 9 & 10 & 11E. This crew worked here until August 1944 obtaining records of fair quality throughout. The Selma Chalk horizon was most continuous with deeper beds being somewhat poorer in quality. It was found during the seismograph program that the Tuscaloosa beds did not give reflections capable of being mapped. Figures 3 and 4 show the results of this work. Figure 3 shows the contours on the Selma Chalk. An anomalous area is indicated in Sections 15, 21, and 22, T 17N-R 9E as shown by this map. The closure is small, probably not exceeding 50 feet in amount.

Figure 4 shows the contours on top of the Glen Rose formation. Here con-

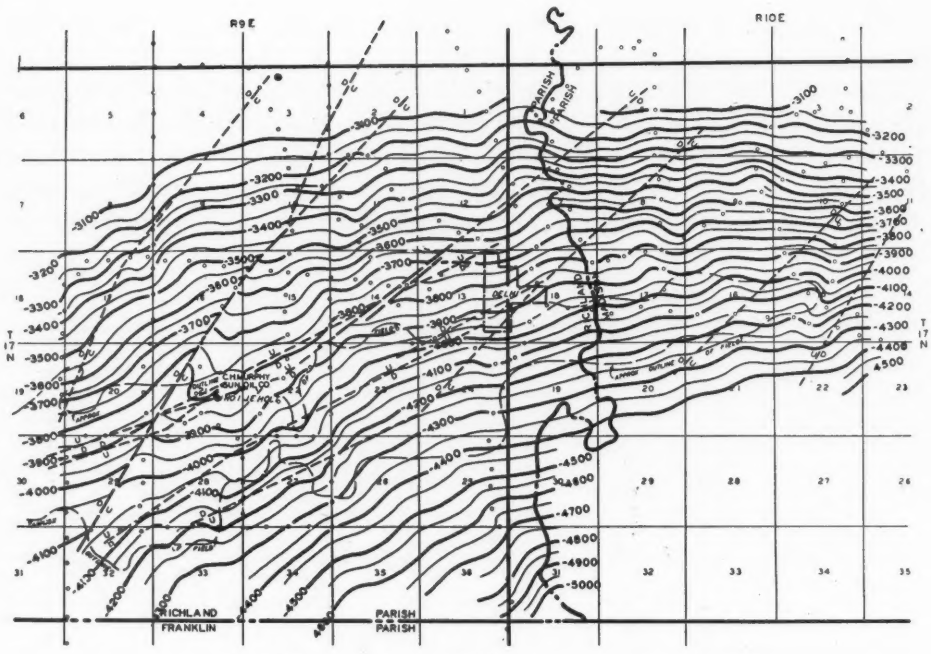

FIG. 4. Map showing seismograph contours on top of Glen Rose.

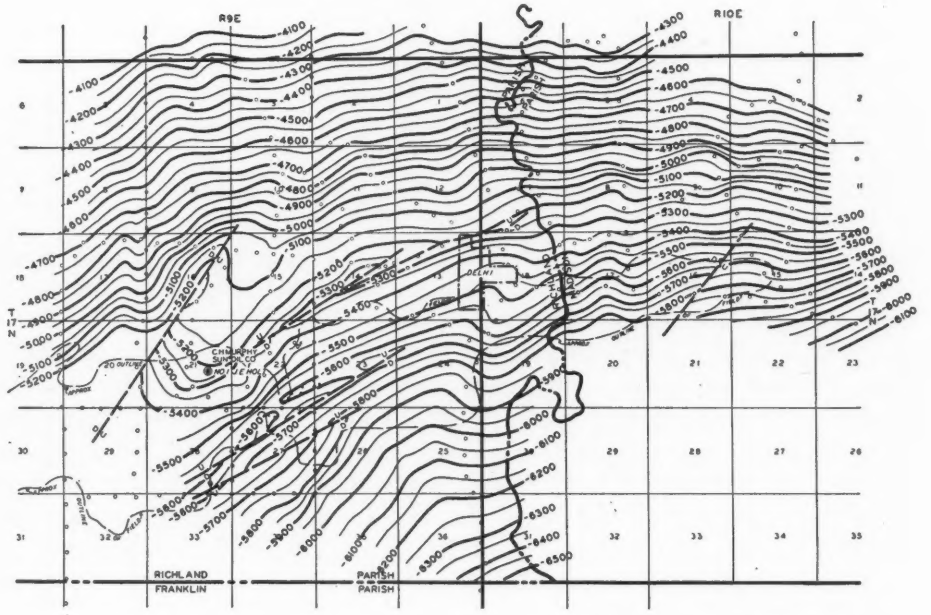

FIG. 5. Map showing seismograph contours on lower Glen Rose or Hosston.

siderable more dip to the southeast exists than is shown on the Selma Chalk. Again a minor anomaly is present in Sections 15, 21, and 22 of T 17N-R 9E. Figure 5 shows contours on lower Glen Rose or Hosston. At this horizon the dip is also strongly to the southeast conforming fairly well, however, with the top of Glen Rose horizon in amount. The anomaly in Sections 15, 21, 22 T 17N-R 9E is a little more pronounced but does not indicate any closure.

Figure 6 shows the unconformity between the Selma Chalk and the lower

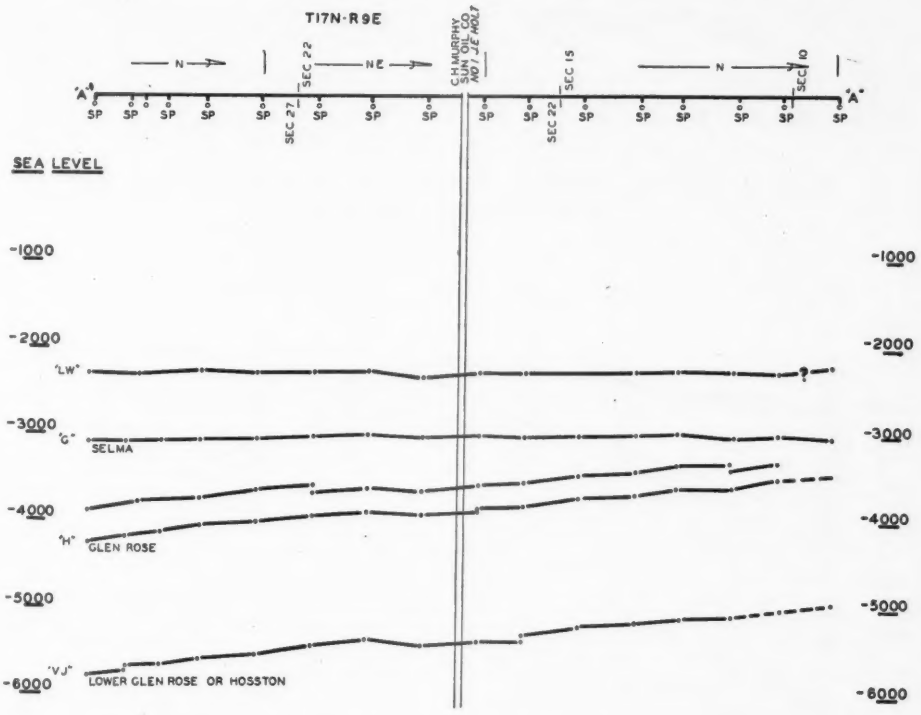

FIG. 6. Cross section AA. Showing unconformity between Upper and Lower beds. Based on seismograph data.

beds taken along the cross section line AA running just east of the discovery well (Fig. 3). A definite unconformity is present just below the Selma Chalk with the deeper beds dipping more steeply to the south.

Following the completion of this seismograph survey, all available acreage on the anomaly in T 17N-R 9E was leased and the Sun Oil Company acquired half interest in all leases held by C. H. Murphy on this anomaly. The Murphy-Sun J. E. Holt No. 1 test was located in Section 21, T 17N-R 9E and spudded November 2, 1944. Late in November 1944, favorable oil showings in Tuscaloosa beds were encountered in the well. Based upon these showings and upon the postulated truncation of Tuscaloosa beds, leases were taken along strike in a northeast-

southwest direction across T 17N- R 8, 9, 10, and 11E and T 16N-R 8E. The J. E. Holt No. 1 well was brought in December 9, 1944 as a good producer from Paluxy beds. Following this discovery well the field has spread in an east-west

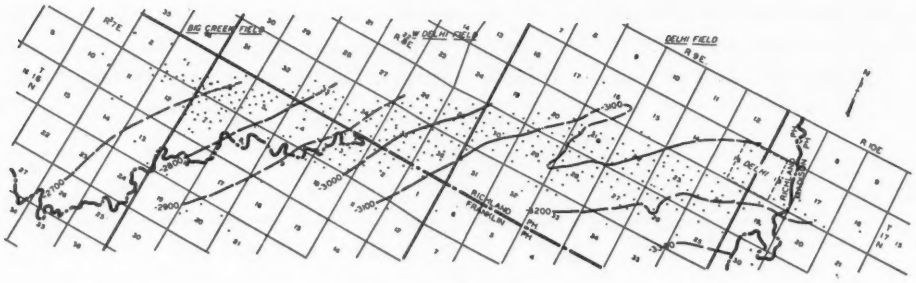

FIG. 7. Map showing geologic data on Selma Chalk. Drawn by A. M. Lloyd and R. B. Totten. Compare with Figure 3.

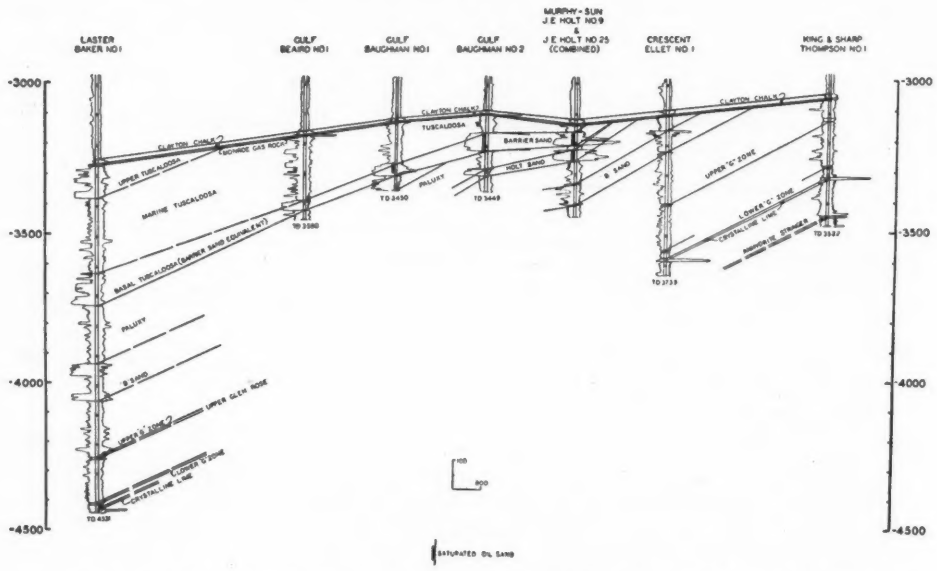

FIG. 8. Geologic cross section showing divergence of beds. Drawn by A. M. Lloyd and R. B. Totten. Compare with Figure 6.

direction and is now approximately 12 miles long and two miles wide with more than 350 producing wells.

Figure 7 shows geologic data on top of Clayton Chalk and is the map presented by Mr. A. M. Lloyd and Mr. R. B. Totten in their paper on the Delhi Field in the fall of 1946. Comparing this with Figure 3 showing seismograph contours, a close resemblance is noted between the two maps in that a strong nose is present in the geologic map where the anomaly was mapped by seismograph.

A comparison of the seismograph cross section (Fig. 6) with the geologic cross section (Fig. 8) is also of some interest. The geologic cross section presented by Mr. Lloyd is much shorter in length and, of course, the dips are greatly exaggerated. However, both sections do show the unconformity and the increased dip in the deeper beds.

In conclusion it can be said that the discovery of the Delhi Field is an illustration of the benefits of an integrated program using both geological and geophysical information in the discovery of oil.

ACKNOWLEDGMENTS

I wish to thank the officials of C. H. Murphy and Sun Oil Company and of the Gulf Refining Company for permission to use the data presented in this paper. Mr. K. L. Dooley was most helpful in preparing the illustrations.

SEISMIC VELOCITY AS A FUNCTION OF DEPTH AND GEOLOGIC TIME*

L. Y. FAUST†

ABSTRACT

Velocity data are compiled from measurements of nearly 1,000,000 feet of section in 500 well surveys in the United States and Canada. Average velocities for shale and sandstone sections are arranged by depth and geologic age. Deviations from the mean values are attributed to lithologic variations. The variations of velocity with depth and time are studied independently in order to develop a quantitative relationship. It is concluded that the velocity for an average shale and sand section is given by the equation $V = 125.3\ (ZT)^{1/6}$, where V is velocity in feet per second, Z is depth in feet, and T is age in years. Velocities in limestone show less definite evidence of increase with age and depth.

INTRODUCTION

This paper is concerned with a study of the velocities of longitudinal seismic waves in sedimentary rocks as a function of the depth of overburden and the geologic age of such rocks. The data have been derived from more than 500 velocity surveys in the files of Amerada Petroleum Corporation. Velocities are tabulated for solid limestone sections and for sections of sand and shale.

Except for a brief reference to the limestone velocities the paper is concerned with the study of velocity in sections of shale and sand. The effect of lithologic variations has been minimized by averaging all measurements at the same depth and age. These velocities are reported together with some discussion of the deviations observed. There is a general agreement with the previous work of Weatherby and Faust (1935). The latter portion of the paper is concerned with the formulation of a quantitative relationship between velocity, depth of burial and geologic time since deposition of the sediments.

The data are presented both graphically and in tabular form.

MEASUREMENTS OF VELOCITY

Selection of Data

The values of velocity to be presented in the tables have been accumulated over a period of fifteen years and are derived from measurements of approximately 1,000,000 feet of section. It is assumed that velocity, $v = f(Z, T, L)$ where Z is depth, T is elapsed time since deposition and L represents other variables, chiefly lithology. Numerical values can be assigned to Z and T but the variations of L such as limestone, shale and sandstone appear at present to be incommensurable. An attempt will be made to hold lithology constant while considering the relationship of velocity to the other variables. The following rules were laid down as the basis of selection for the present study:

* Manuscript received by the Editor December 18, 1950.

† Amerada Petroleum Corporation, Tulsa, Oklahoma.

Interval of Measurement

An interval of 1,000 feet was chosen as the standard for measurement. Any values derived from the measurement of shorter intervals were questioned because the errors of measurement assume increasing importance and variations in lithology tend to obscure the relationship of velocity to depth and geologic time. Since most surveys are conducted with shot points located about 800 to 1,000 feet from the top of the well, ray curvature would result in an error at depths less than 2,000 feet. To avoid this error the first interval below the surface was extended from the bottom of the shot hole, or a datum plane quite close to that depth, usually about 50 feet, to 2,000 feet. Below 2,000 feet the error caused by ray curvature is small.

Lithologic Variations

Shale and sand were accepted as representing equivalent sections. The terms "sand" and "sandstone" are used interchangeably in this paper. No limestone sections of 50 feet or more were allowed in the measurement of 1,000-foot shale and sand sections, and the limestone velocities reported were for solid lime sections with no appreciable breaks. All sections indicated as "calcareous" were eliminated. This resulted for example in the rejection of most Pennsylvanian velocity measurements in Kansas and all but the bottom 1,000 feet of Black Shale in West Texas. If shale and sand were to have been reported separately most of the data used would have been rejected since changes from shale to sand occur generally in much shorter intervals than the usual 500-foot interval of velocity measurements.

Haskell (1941) has shown variations in the rate of velocity increase for sandstone and shale in Tertiary sections and has reported somewhat higher velocities for sandstone. While some data are given in this paper in general confirmation of Haskell, larger variations in velocity have been found which are probably caused by different degrees of cementation. It was decided therefore to average all velocity measurements of non-calcareous sections of the same age and depth range with the expectation that the value so derived would best represent the velocity of an average shale and sand section.

Weighting

When an interval velocity measurement was accepted it was given equal weight with each of the other values in the same age and depth range in the determination of the mean values. A moderately high standard for acceptable quality of the seismic records was adopted. As a result of following the above rules, about 300 velocity surveys yielded one or more accepted values.

Travel times were corrected to the vertical in the usual manner. The interval velocity for each depth interval was computed by dividing the difference in depth ΔZ of the top and bottom of the section measured by the difference in vertical times Δt for those depths. No values were derived from time depth curves.

TABLE 1

COMPILED VELOCITY MEASUREMENT AND CONCLUSIONS FOR SHALE AND SAND SECTIONS

Mean Depth Z (feet)	Depth Interval ΔZ (feet)	Time Interval Δt (sec.)	Interval Velocity $\Delta Z/\Delta t$ (ft./sec.)	No. of Wells	Location of Wells	Mean Deviation (feet/sec.)	Maximum Deviation (feet/sec) Minus	Maximum Deviation (feet/sec) Plus	$V=\alpha_m Z^{1/6}$ dZ/dt (feet/sec.)	$V=\alpha(ZT)^{1/6}$ dZ/dt (feet/sec.)	Mean Depth Z (feet)
TERTIARY (POST EOCENE)											
1,025	1,950	.287	6,800	71	C T L Mi N	288	620	1,250	6,900	6,840	1,025
2,500	1,000	.131	7,660	63	C T L Mi	511	1,450	2,140	8,080	7,940	2,500
3,500	1,000	.123	8,160	63	C T L Mi	470	1,140	2,590	8,500	8,400	3,500
4,500	1,000	.115	8,670	64	C T L Mi	455	1,330	2,830	8,900	8,750	4,500
5,500	1,000	.112	9,220	54	C T L	566	1,660	2,960	9,200	9,060	5,500
6,500	1,000	.105	9,520	53	C T L	527	1,700	1,680	9,450	9,290	6,500
7,500	1,000	.101	9,860	48	C T L	701	2,000	2,140	9,700	9,530	7,500
8,500	1,000	.098	10,220	31	C T L	824	1,760	1,340	9,900	9,730	8,500
9,500	1,000	.094	10,670	23	C T	910	1,850	2,150	10,100	9,910	9,500
10,500	1,000	.090	11,090	13	C	960	2,090	2,010	10,250	10,090	10,500
11,500	1,000	.088	11,300	2	C	200	200	200	10,450	10,230	11,500
EOCENE											
1,025	1,950	.277	7,050	11	Mi L Al C T Co W Ar	502	580	1,030	7,350	7,450	1,025
2,500	1,000	.126	7,940	12	Mi L Al T Co C Ar	364	790	1,060	8,600	8,630	2,500
3,500	1,000	.118	8,510	12	Mi Al L Mo	598	950	2,390	9,100	9,120	3,500
4,500	1,000	.109	9,190	7	Mi Al L C	581	790	1,510	9,500	9,530	4,500
5,500	1,000	.099	10,070	7	T Mi L C	663	920	1,510	9,800	9,849	5,500
6,500	1,000	.099	10,030	3	T Mi	730	1,100	600	10,100	10,120	6,500
7,500	1,000	.096	10,310	4	T Mi	567	1,400	950	10,350	10,380	7,500
11,000	2,000	.179	11,130	4	T	617	930	850	11,050	11,070	11,000
CRETACEOUS											
1,025	1,950	.256	7,620	10	Mo D T Ar L W A	235	800	430	8,200	8,450	1,025
2,500	1,000	.114	8,750	14	D T Ar L N Co W A	431	920	630	9,500	9,820	2,500
3,500	1,000	.101	9,860	13	Mi Mo D T Ar L W A Co	464	1,240	840	10,100	10,380	3,500
4,500	1,000	.090	11,060	3	Mi T W	50	70	40	10,550	10,810	4,500
5,500	1,000	.088	11,320	7	T Mi Ar W	274	440	410	10,950	11,190	5,500
6,500	1,000	.085	11,710	4	T Ar L W	1,097	1,980	2,190	11,250	11,510	6,500
7,500	1,000	.085	11,800	2	T D	700	700	700	11,500	11,800	7,500
8,500	1,000	.083	12,050	3	T Mi Co	465	350	700	11,750	12,050	8,500
JURASSIC-TRIASSIC											
725	1,450	.182	7,950	1	M	—	—	—	8,460	8,670	725
4,100	1,150	.105	11,000	1	D	—	—	—	11,350	11,520	4,100
4,400	1,300	.109	11,940	1	D	—	—	—	11,450	11,690	4,400
5,000	700	.055	12,670?	1	W	—	—	—	11,600	11,970	5,050
6,100	800	.065	12,330?	1	Mo	—	—	—	12,150	12,360	6,100
7,900	800	.066	12,200?	2	L Co	500	500	500	12,700	12,910	7,900
PERMIAN											
1,025	1,950	.225	8,650	7	T O M K	401	730	870	9,100	9,550	1,025
2,500	1,000	.100	10,000	2	T	500	500	500	10,550	11,070	2,500
3,500	1,000	.093	10,750	1	T	—	—	—	11,150	11,720	3,500
4,500	1,000	.081	12,300	2	T	400	400	400	11,650	12,220	4,500
5,500	1,000	.080	12,440	1	T	—	—	—	12,000	12,650	5,500
6,500	1,000	.079	12,600	2	M	200	200	200	12,400	13,000	6,500
8,000	2,000	.072	12,350	3	M T	766	850	1,000	12,850	13,460	8,000
PENNSYLVANIAN											
1,025	1,950	.207	9,420	18	O K	274	530	530	9,750	9,770	1,025
2,500	1,000	.090	11,110	14	O K	266	490	590	11,250	11,320	2,500
3,500	1,000	.085	11,720	18	T O	280	620	580	11,900	12,000	3,500
4,500	1,000	.082	12,230	18	T O	402	1,180	1,320	12,400	12,500	4,500
5,500	1,000	.079	12,650	14	T O	516	1,150	1,050	12,800	12,910	5,500
6,500	1,000	.079	12,710	7	T O	487	910	990	13,150	13,270	6,500
7,500	1,000	.075	13,320	5	T M O	576	1,320	680	13,450	13,610	7,500
8,500	1,000	.075	13,390	4	T O	743	1,110	610	13,700	13,900	8,500
9,500	1,000	.077	13,020	4	T O	1,323	1,020	1,980	14,000	14,160	9,500
10,500	1,000	.071	14,030	3	T M O	310	330	470	14,200	14,390	10,500
11,500	1,000	.069	14,500	2	M O	150	150	150	14,400	14,620	11,500

TABLE 1—*Continued*

Mean Depth Z (feet)	Depth Interval ΔZ (feet)	Time Interval Δt (sec.)	Interval Velocity $\Delta Z/\Delta t$ (ft./sec.)	No. of Wells	Location of Wells	Mean Deviation (feet/sec.)	Maximum Deviation (feet/sec.) Minus	Plus	$V=\alpha_m Z^{1/6}$ dZ/dt (feet/sec.)	$V=\alpha(ZT)^{1/6}$ dZ/dt (feet/sec.)	Mean Depth Z (feet)
					MISSISSIPPIAN						
1,025	1,950	.195	10,000	1	I	—	—	—	10,400	9,950	1,025
3,150	600	.046	13,000?	1	I	—	—	—	12,400	12,000	3,150
7,300	650	.045	14,350?	2	O	850	850	850	14,300	13,800	7,300
					DEVONIAN						
2,000	400	.032	12,530?	4	O A P	425	830	770	12,000	11,400	2,000
3,000	350	.028	13,070?	4	O A P	657	1,150	930	12,800	12,190	3,000
4,300	350	.025	13,900?	3	O A P	266	400	300	13,500	12,910	4,300
5,800	500	.036	14,000?	4	O A Ma	520	1,200	1,100	14,400	13,610	5,800
					ORDOVICIAN						
2,320	800	.062	12,800?	1	O	—	—	—	12,500	12,300	2,320
5,780	800	.055	14,360?	1	O	—	—	—	14,500	14,320	5,780
9,880	540	.036	14,880?	1	M	—	—	—	15,750	15,670	9,880

KEY TO LOCATION OF WELLS: (A)lberta; (Al)abama; (Ar)kansas; (C)alifornia; (Co)lorado; North (D)akota; (I)llinois; (K)ansas; (L)ouisiana; New (M)exico; (Ma)nitoba; (Mi)ssissippi; (Mo)ntana; (N)ebraska; (O)klahoma; (P)ennsylvania; (T)exas; (W)yoming.

Tabulation of Data

The results of these measurements for shale and sand sections are given in Table 1 whose columns indicate: (1) The mean depth (Z) of the section measured; (2) the interval measured (ΔZ); (3) the average time interval (Δt) for the depth interval ΔZ; (4) the mean value of the interval velocity ($\Delta Z/\Delta t$); (5) the number of wells used in the determination; (6) the coded location of the wells; (7) the mean deviation from the mean of the interval velocities determined by dividing the arithmetic sum of individual deviations by the number of wells; (8) and (9) the maximum deviations from the mean velocity, minus and plus respectively. The key to the location code is given at the bottom of the table. The other columns will be explained in the course of the discussion.

Table 1 discloses that the mean values of the velocity increase with depth and with geologic time in confirmation of Weatherby and Faust (1935).

Although a wide range of geologic provinces are included in many of the determinations, there was usually little evidence of systematic deviation from the mean from one area to another. Two exceptions are the Devonian of the Appalachian Basin and the Eocene and Cretaceous of Southwest Texas. In these cases the velocities are of the order usually observed at depths 3,000 feet greater. These anomalous values are thought to be associated with an unusually high degree of cementation. The values reported in the earlier paper for Eocene, Cretaceous and Devonian were influenced disproportionately by wells in the above-mentioned regions and are not believed to represent average sections. Narvarte (1946) has confirmed the high value of shallow Devonian in the Appalachian Basin. There also appear to be unusually high velocities associated with piedmont regions. Whether these are a result of diastrophism or of previous greater depth of burial is beyond the scope of this paper.

Table 2 gives values of limestone velocities which are believed to be representative of velocities in solid limestone. A velocity study was made of a large number of limestone sections of varying thickness and homogeneity and the one or two best determinations for each age were used in Table 2. The other measurements were used for confirmation of the better data. The three preferred determinations are for Cretaceous, Permian and Cambro-Ordovician which demonstrate increased velocity with age. However two of the other velocities listed are deemed acceptable and show no increase. The value of near surface velocities

TABLE 2

MEASURED VELOCITIES IN SOLID CRYSTALLINE LIMESTONE AT THE DEPTHS AND INTERVALS INDICATED

Age	Mean Depth (feet)	Interval (feet)	Velocity $\Delta Z/\Delta T$ (ft./sec.)	Number of Wells	Location
Cretaceous	7,200	2,600	18,600	1	T
Permian	5,000	2,200	19,400	1	M
Pennsylvanian	3,300	1,000	19,400	1	T
Mississippian	9,000	700	19,200?	2	T
Devonian	7,500	1,000	19,400	2	O
Cambro-Ordovician	5,000	1,400	21,000	2	T

reported by Weatherby and Faust are considerably lower, ranging from 11,000 feet per second for Cretaceous to 17,400 feet per second for Cambro-Ordovician. If these velocities have not been affected by weathering there is an increase of velocity with depth for limestone.

Velocity Variations in Shale and Sandstone

Table 3 shows a comparison of Post-Eocene Tertiary velocities in California and the Gulf Coast. On average the Gulf Coast velocities are about 230 feet per second lower. A less rigorous screening process was possible for the California wells because detailed well logs were not available. Apparently the large number of measurements has averaged out velocity variations due to lithologic changes although the maximum deviations are the highest listed. Stulken (1941) has reported regional velocity changes in the Bakersfield area of California which could explain the large deviations of Table 3. M. C. Born (private communication) has pointed out, however, that for the San Joaquin Valley as a whole the major portion of the regional change in velocity occurs in the upper 4,000 feet of sediments. It may be concluded that Table 3 confirms the wide variations in velocity and demonstrates that significant values of velocity are obtained by the method of averaging.

For measurements of the type shown in Table 1 it is difficult to attach significance to a probable error. It is believed that the inclusion of the number of wells involved in each average, the mean and maximum deviations and the geographic distribution may be sufficient for evaluation of the data. The maximum deviations in some cases in Table 1 are as great as the range of velocities within

the given age but minimum and maximum values also demonstrate increased velocity with depth. While some major errors may have passed scrutiny, it is more probable that these variations are a measure of lithologic changes. Such seems indicated from the following distribution of the velocities. For Tertiary from 2,000–3,000 feet the number of measurements closest to each following velocity value are: 1 at 6,300, 4 at 6,700, 3 at 6,900, 7 at 7,100, 7 at 7,300, 6 at 7,500, 10 at 7,700, 4 at 7,900, 7 at 8,100, 6 at 8,300, 2 at 8,500, 5 at 8,900 and 1 at 9,100. For Pennsylvanian from 50–2,000 feet the distribution is: 1 at 8,900, 1 at 9,000, 3 at 9,100, 1 at 9,200, 3 at 9,300, 1 at 9,400, 3 at 9,500,

TABLE 3

COMPARISON OF TERTIARY (POST EOCENE) VELOCITIES IN TWO AREAS

(Despite the large deviations the velocities are in good agreement indicating that lithologic variations have been averaged out)

Mean Depth (feet)	Interval (feet)	CALIFORNIA				GULF COAST			
		Velocity $\Delta Z/\Delta T$ (ft./sec.)	Number of Wells	Maximum Deviation (ft./sec.)		Velocity $\Delta Z/\Delta T$ (ft./sec.)	Number of Wells	Maximum Deviation (ft./sec.)	
				Minus	*Plus*			*Minus*	*Plus*
1,025	1,950	6,870	52	690	1,180	6,600	18	500	580
2,500	1,000	7,730	50	1,520	2,070	7,360	13	690	610
3,500	1,000	8,110	53	1,090	2,649	8,390	10	690	610
4,500	1,000	8,690	52	1,350	2,810	8,530	12	630	890
5,500	1,000	9,240	46	1,680	2,940	8,890	8	590	890
6,500	1,000	9,600	46	1,780	1,600	8,930	7	430	370
7,500	1,000	9,910	41	2,050	2,090	9,560	7	670	1,070
8,500	1,000	10,220	31	1,780	1,340	10,300	4	300	600
9,500	1,000	10,670	23	1,850	2,150	10,350	1	—	—

2 at 9,600, 2 at 9,700, 1 at 9,800, 1 at 9,900 and 2 at 10,000. These distributions are representative.

The velocities at the shallower depths, being the mean generally of the larger number of observations, are undoubtedly more significant than the velocities given for the greatest depths. In order of increasing uncertainty, the velocity measurements for various age rock should be listed as follows: Pennsylvanian, Tertiary (Post-Eocene), Eocene, Cretaceous, Permian, Jurassic-Triassic, Devonian, Mississippian and Ordovician.

VELOCITY AS A FUNCTION OF DEPTH AND GEOLOGIC TIME

Shale-Sandstone Velocities Versus Depth

Figure 1, derived from Table 1, columns (1) and (4), discloses an increase in velocity with age and depth, and also shows that the rate of increase of velocity with depth is greatest for the shallowest depths. The greatest rate of increase at shallow depths occurs for older sediments. This type of increase suggests the use of the equation:

$$v = \alpha Z^{1/n} + \gamma \qquad (1)$$

where v = velocity at depth Z, i.e. the time derivative of Z, and α, γ and n are constants for each curve. As a first approximation let $\gamma = 0$ and

$$v = \alpha Z^{1/n}. \tag{2}$$

Equation (2) is the basic equation of the "Blondeau Weathering" (The late E. E. Blondeau developed a weathering correction method based on equation (2). Although never published the "Blondeau Weathering" is generally known.) which has been modified by Banta (1941). Integration of equation (2) gives

$$Z^B = \alpha B t$$

whence

$$\log t = B \log Z + K \tag{3}$$

differentiating (3),

$$v = Z/Bt = \overline{V}/B \tag{4}$$

where t is the vertical time, $\overline{V}$ the average velocity to depth Z, $B = (n-1)/n$ and K is a constant.

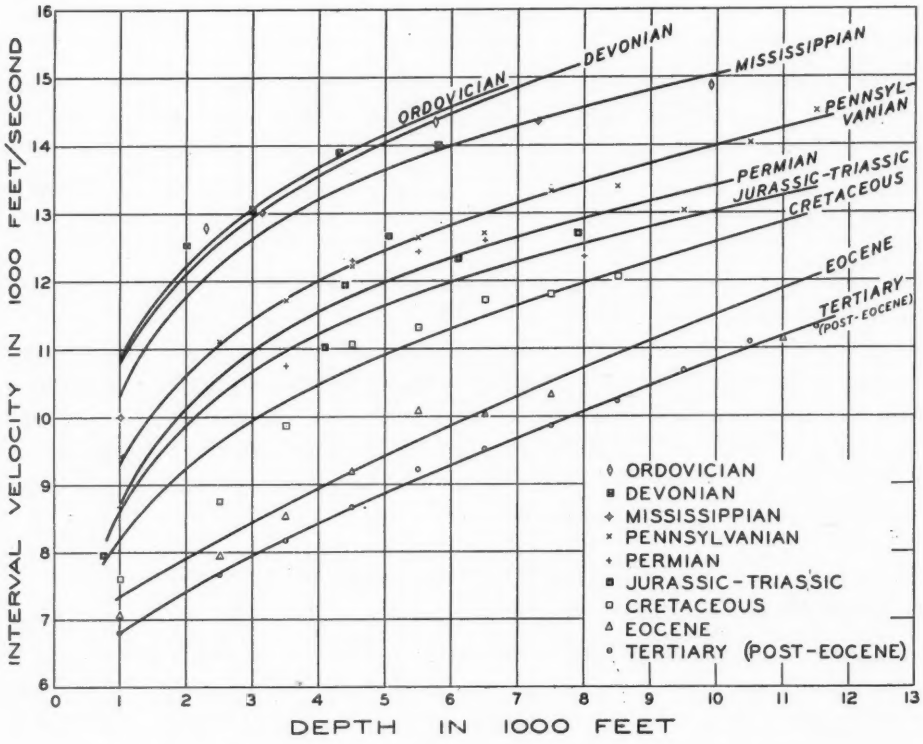

FIG. 1. Interval velocities ($\Delta Z/\Delta t$) plotted against depth (Z) for each age group from columns (1) and (4) of Table 1.

A summation of the measured quantities ΔZ and Δt (columns (2) and (3) of Table 1) taken from the surface to the bottom of any interval yields a value of Z and a corresponding value of t. The values of Δt from 0 to 50 feet were obtained to a first approximation by plotting the values of Figure 1 logarithmically and

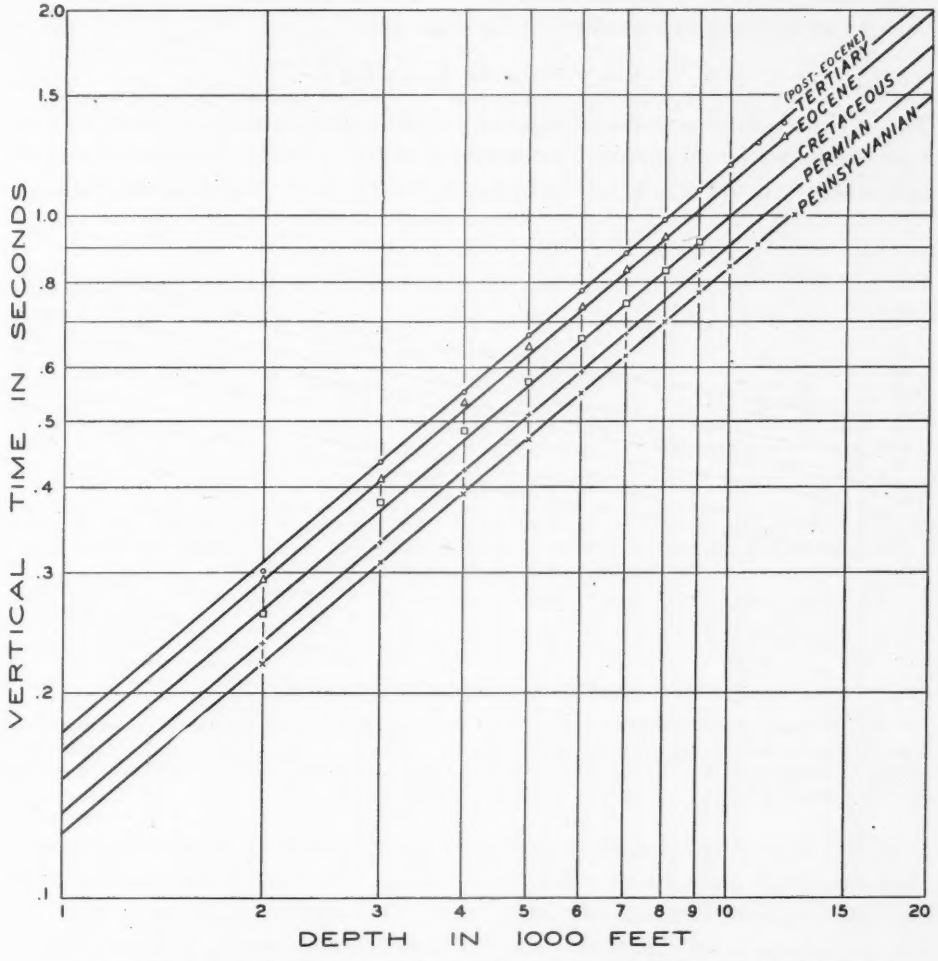

FIG. 2. Vertical time against depth for shale and sand on logarithmic scale. Straight lines confirm relationship $V=\alpha Z^{1/n}$. All slopes equal $(n-1)/n$ where $n=6$.

solving. The time to 50 feet obtained in this manner varied from 0.014 second for Tertiary to 0.010 for Pennsylvanian. A summation for each succeeding interval will give a set of values of Z and t for each age group wherein such data are available. These values are plotted logarithmically in Figure 2. Equation (3) states that if the velocity function is of the form of equation (2) then values of Z and t will plot logarithmically on a straight line. Figure 2 shows that this relation-

ship is fulfilled for each age group and consequently that equations (2), (3) and (4) apply. It was not evident from equation (2) that the lines of all age groups would have identical slopes. The lines of Figure 2 are drawn with slope $B=0.833$ or $n=6$. It is now possible to determine the value of v for any depth by equation (4). These results are plotted on log-log coordinates in Figure 3 which represents velocity at each depth according to the equation:

$$\log v = \log \alpha_m + 1/n \log Z. \tag{5}$$

This is the logarithmic form of equation (2) with α_m a velocity constant for each curve and $n=6$ for all curves. The dashed lines are taken from Figure 1 for those ages where data are insufficient to be plotted in Figure 2. The inclusion of the in-

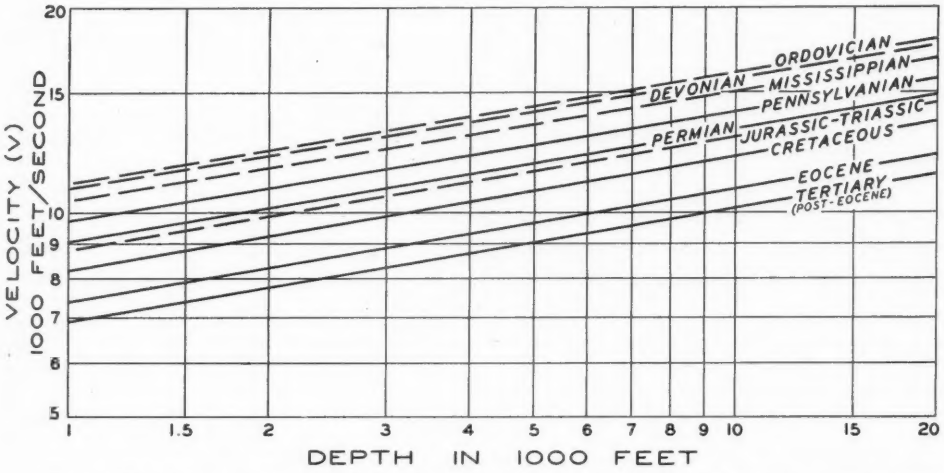

FIG. 3. Velocity versus depth on logarithmic scale for each geologic age. Solid lines are derived from Figure 2. Age groups with incomplete data are shown by dashed lines approximated from Figure 1. Slopes are equal to $1/n$ where $n=6$. The equations of each line are of the form $\log V = \log \alpha_m + (1/6)\log Z$, where α_m is a velocity constant for each age.

complete data of the dashed lines may be questioned since more data when accumulated will undoubtedly alter these values. However the magnitudes of the velocities confirm qualitatively an increase in velocity with age and considering the deviations to be expected, the velocity depth relationship is descriptive.

Equation (5) makes possible the determination of α_m for each age. To the extent that equation (2) holds, α_m is numerically equal to the velocity at a depth of one foot. Whether or not equation (2) holds at very shallow depths, the values of α_m are proportional to the velocities at any fixed depth within the range measured. Table 4 lists geologic age, geologic time after Holmes (1946) and α_m. The questioned values are derived from the dashed lines.

Effect of Intra-Age Time Variations

Since velocity evidently increases with geologic time, it remains to be determined to what extent the difference in geologic time within an age group has

affected the data of Figure 3. If sufficient samples were taken over a wide enough area the effect of age should be completely eliminated from the shallowest values for sediments of all age groups. For the Post-Eocene Tertiary, it is obviously impossible to average velocities from young and old sediments at great depth while such an average could be quite satisfactory for sediments older than Tertiary.

TABLE 4

GEOLOGIC AGE, GEOLOGIC TIME FROM HOLMES (11) AND CORRESPONDING VALUES OF VELOCITY CONSTANTS, α_m, DERIVED FROM FIGURE 3

GEOLOGIC AGE	GEOLOGIC TIME	VELOCITY CONSTANT α_m
Tertiary (Post-Eocene)	26×10^6 Years	2,190
Eocene	43×10^6 Years	2,332
Cretaceous	93×10^6 Years	2,607
Jurassic-Triassic	152×10^6 Years	2,823?
Permian	192×10^6 Years	2,866
Pennsylvanian	220×10^6 Years	3,047
Mississippian	245×10^6 Years	3,235?
Devonian	284×10^6 Years	3,380?
Ordovician	390×10^6 Years	3,439?

TABLE 5

INTERVAL VELOCITIES FOR SHALE AND SAND SECTIONS OF IDENTICAL GEOLOGIC AGE TO SHOW VARIATION OF VELOCITY WITH DEPTH INDEPENDENT OF GEOLOGIC TIME. EACH VALUE REPRESENTS A SINGLE VELOCITY MEASUREMENT

HOGSHOOTER-OSWEGO (Pennsylvanian)		MIDWAY (Eocene)		TOP 1000 FT. VICKSBURG (Oligocene)	
Mean Depth (feet)	Interval Velocity (feet)	Mean Depth (feet)	Interval Velocity (feet)	Mean Depth (feet)	Interval Velocity (feet)
2,125	10,800	1,230	7,200	750	6,500
2,200	10,500	2,260	8,010	2,500	7,600
2,900	11,200	2,500	8,100	4,030	7,800
3,250	11,500	3,000	8,250	4,500	8,550
3,500	11,700	3,720	8,370	5,500	8,770
3,600	11,600	3,900	8,400	5,900	8,750
4,100	11,500	4,500	8,700	8,500	9,700
4,200	11,950	4,800	9,250		
5,175	12,100	6,450	9,730		
5,670	12,400	7,460	9,600		
7,600	13,400				
7,640	13,200				

A check on this reasoning can be made by measuring a given section at different depths. Table 5 gives such values for the Hogshooter-Oswego interval of the Pennsylvanian. The values are partly new and partly from Weatherby and Faust (1935). This series is believed to be quite reliable since a large number of velocity measurements was available and it was possible to select that group wherein the lithology is uniform. Also shown in Table 5 are velocities in the

Midway (Eocene) and the top thousand feet of Vicksburg (Oligocene). The shallowest values have been corrected to a first approximation for the difference between interval velocity and v at the mean depth and for the effect of ray curvature. Each interval velocity listed is taken from a single well. The values are plotted logarithmically in Figure 4 and show that the slope is such that $n=6$. This confirms the results of Figure 3 and indicates that the velocity as a function of depth only is given by

$$v = \alpha_m Z^{1/6}. \tag{6}$$

In column (10), Table 1, are given the values of velocity ($v=\alpha_m Z^{1/6}$) as de-

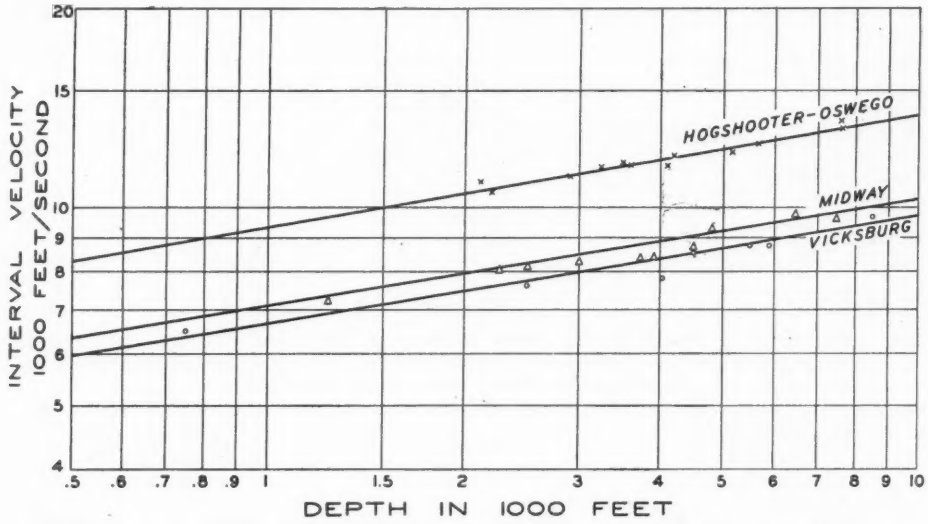

FIG. 4. Interval velocities for shale and sand sections of identical age plotted against depth. Pennsylvanian, Eocene and Oligocene sections confirm the conclusion of Figure 3 that $V=\alpha_m Z^{1/6}$.

termined by Figure 3 for the appropriate depth Z. The value of v should be greater than $\Delta Z/\Delta t$, especially at the shallower depths. The comparison of column (10) with column (4) is generally satisfactory. However, the greatest Post-Eocene Tertiary depths show a definite tendency for the measured values to exceed the velocity values of column (10). It is exactly for these depths in the Tertiary that an effect of time variation within the age limit was predicted. Although the variation could be ascribed to either lithologic change or failure of the velocity function, it is significant that the velocities for deepest Tertiary approach but do not generally exceed the corresponding velocities of the next older age.

Shale Versus Sand Velocities

It is possible by the use of equation (6) to compare velocities of shale and sand under similar conditions. Table 6 attempts such a comparison between the

basal thousand feet of Wilcox (Eocene) sand and the underlying Midway (Eocene) shale. Each line of this table shows measurements in a single well. The first line, for example, lists values from velocity survey number 13. Listed in order are: the mean depth of the Wilcox section; the measured velocity (corrected); the appropriate value of v from equation (6); the signed deviation of the measured velocity from v; the mean depth of the Midway shale; the measured velocity; the appropriate value of v from equation (6); the signed deviation of the measured velocity from the value of v. The second line compares similar data for velocity survey number 204 and the remaining lines are derived in the same manner from other surveys. While the deviations of the sand velocities range

TABLE 6

COMPARISON OF EOCENE SAND AND SHALE VELOCITIES LISTED SIDE BY SIDE FROM THE SAME WELL.
(Deviation is from the value of v as taken from figure 3. Sand shows more variation in velocity while a comparison of the algebraic mean of the deviations suggests that sand velocities may be slightly higher than shale velocities on average when depth and age are held constant)

WILCOX (SAND)				MIDWAY (SHALE)			
Mean Depth	Observed Velocity	v	Deviation	Mean Depth	Observed Velocity	v	Deviation
460	6,510	6,400	110	1,230	7,200	7,500	−300
1,025	7,690	7,300	390	2,500	8,100	8,500	−400
2,300	8,400	8,400	0	3,000	8,250	8,800	−550
3,000	8,500	8,800	−300	3,720	8,370	9,100	−730
3,000	8,600	8,800	−200	3,900	8,400	9,200	−800
3,500	7,900	9,000	−1,100	4,500	8,700	9,400	−700
3,750	8,400	9,100	−700	4,800	9,250	9,600	−350
5,500	9,400	9,750	−300	6,450	9,730	10,000	−270
6,500	10,450	10,000	450	7,460	9,600	10,250	−650
		Algebraic Mean	−183			Algebraic Mean	−528

from minus 1,100 to plus 450, the deviations for shale vary only from minus 800 to minus 270. The algebraic mean of the deviations of sand is minus 183 and of shale is minus 528 feet per second. This direct comparison shows the sand velocities to be 350 feet per second greater than shale velocities on average. Other evidence of sand and shale velocity differences can be found from a comparison of Vicksburg velocities of Table 5 with the appropriate Tertiary velocities of Table 1. The upper 1,000 feet of Vicksburg is mostly shale and shows somewhat lower values for velocity than the more sandy section of the average Tertiary.

The Hogshooter-Oswego section of Table 5 is chiefly shale but contains about 14 per cent of limestone. If corrected for this limestone the velocities would fall about six hundred feet per second below the values for the average Pennsylvanian section. The examples given of shale versus sand velocities tend to justify the inclusion of both types of sediments in an average section. The large range of velocity values shown by the maximum deviations of Table 1 is believed to be

due at least in part to varying degrees of cementation. The velocity variations in some cases represent time variations of six hundredths of a second in 1,000 feet and are too large therefore to be attributed to error of measurement. Until a quantitative scale of lithologic variation can be applied in the prediction of velocity deviations the problem of deriving velocity values from a study of well logs is unsolved. Despite this unknown the effect of other variables on velocity can be studied if lithology can be held constant by the method of averaging and the further fitting of such averaged values to a smooth curve. To the extent that this has been accomplished the best values for velocity for an average shale and sand section of constant lithology and geologic age are given by equation (6). The relationship of velocity to geologic time (T) remains to be determined.

Relationship of Velocity, Depth and Geologic Time

The values of geologic time and the corresponding velocity constant α_m from

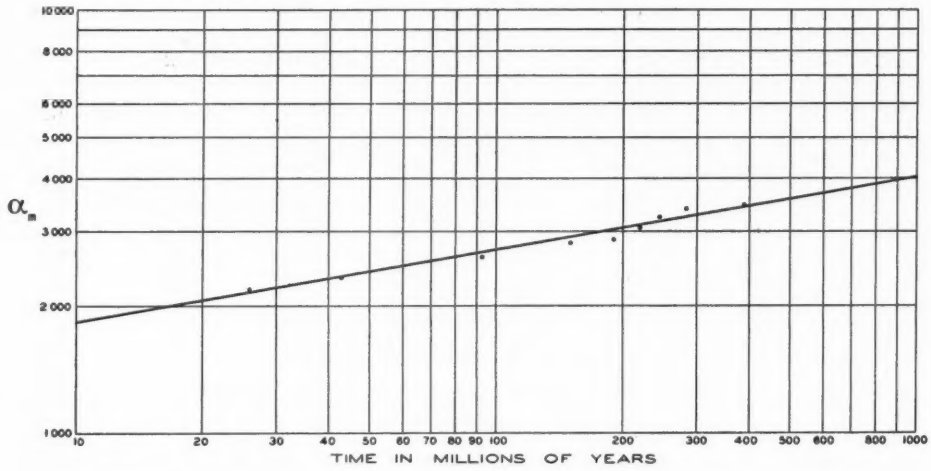

FIG. 5. Values of α_m for each curve of Figure 3 plotted against geologic time (T). The slope is $1/n$ where $n=6$; hence $\alpha_m=\alpha T^{1/6}$ and $V=\alpha(ZT)^{1/6}$.

Table 4 are plotted in Figure 5. The alignment may be considered to be satisfactory. This curve is of the form

$$\alpha_m = \alpha T^{1/6} \tag{7}$$

where T is geologic time in years and α is a constant. The same result would be obtained by plotting interval velocities, velocities (v) or average velocities to any constant depth against time and reducing to $Z=1$ by equation (2).

Combining equations (6) and (7) the formula for the velocity as a function of depth and geologic time is

$$v = \alpha(TZ)^{1/6} \tag{8}$$

where α is given presently the value of 125.3 and is numerically equal to velocity in feet per second when $TZ=1$.

Two other time scales show the same relationship but the value of α is determined as 121.5 by the scale of *The Internal Constitution of the Earth* and 127.2 by *U. S. Geological Bulletin 967*. In each instance the time in years has been taken as the mean value with the exception of Post-Eocene Tertiary where a value somewhat higher than the mean is assumed for reasons discussed previously. The values for equation (8) are listed in column (11) of Table 1 for comparison. A graphical comparison is shown in Figure 6 where the interval velocities of Table 1, column (4), are plotted logarithmically against the product ZT. Equa-

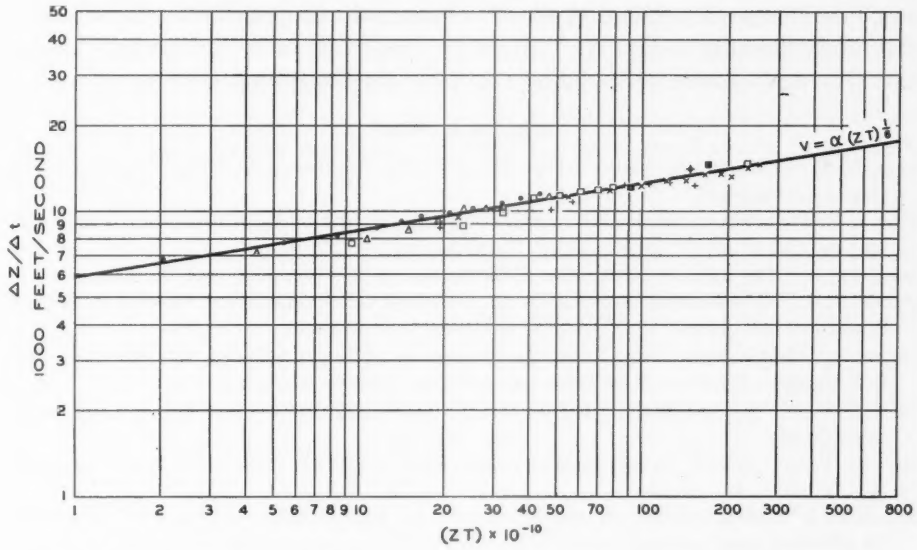

FIG. 6. Comparison of equation (8) expressed by the straight line with the interval velocities of Table 1 column (4) plotted logarithmically against the product ZT.

tion (8) is represented by the straight line. In accordance with a previous argument, the values for T for the Post-Eocene Tertiary range from the mean value at shallow depths to larger values corresponding to the measured section at great depths.

There is some evidence, including the early work of Lester (1932), that equation (8) may hold approximately at depths of less than ten feet and in recent sediments, i.e., in the so-called "weathered zone." However, quantitative evidence is lacking, chiefly because of the absence of an acceptable value of T where measurements of velocity have been made. It is hoped that such measurements can be obtained at places where T is known with some degree of certainty by the Carbon 14 isotope method. Such an investigation might determine the presence and value of a small constant term on the right-hand side of equation (8).

The extrapolation of equation (8) to great depths of sedimentary sections results in velocities that are not unreasonable. As an extreme example, the value of v for Ordovician shale and sand at a depth of 30,000 feet is predicted as 18,900 feet per second.

Re-examination of the data discloses that p expressed in pounds pressure per square inch can be substituted for Z in equation (8) without altering the value of the exponent and with slight modification in the numerical value of α.

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BIBLIOGRAPHY

Banta, H. E. "A Refraction Theory Adaptable to Seismic Weathering Problems," *Geophysics, VI* (July, 1941) 245–253.

Faust, L. Y. "Influence of Geological Factors on Longitudinal Seismic Velocities," Presented at mid-year meeting of S.E.G., Dallas, Texas, November 29, 1935.

Gutenberg, B., "The Internal Constitution of the Earth," 66. McGraw-Hill, 1939.

Haskell, N. A., "The Relation Between Depth, Lithology and Seismic Wave Velocity in Tertiary Sandstones and Shales," *Geophysics*, VI, (October 1941) 318–326.

Holmes, A. "The Geological Time Scale." *Trans. Geol. Soc.*, Glasgow 20, 1946. Reproduced by J. H. F. Umbgrove, *The Pulse of the Earth*, 351–352. (See footnote page 352.)

Lester, O. C. Jr., "Seismic Weathered or Aerated Surface Layer," *Bulletin A.A.P.G.*, 16, (December, 1932) 60–64.

Narvarte. P. E. "On Well Velocity Data and Their Application to Reflection Shooting." *Geophysics*, XI (January, 1946) 66–81.

Stulken, E. J. "Seismic Velocities in the Southeastern San Joaquin Valley of California," *Geophysics*, VI (October, 1941) 327–355.

U. S. Geological Survey Bulletin 967, Plate 5 (1950).

Weatherby, B. B. and L. Y. Faust, "Influence of Geological Factors on Longitudinal Seismic Velocities," *Bulletin A.A.P.G.*, 19 (January, 1935) 1–8.

NORMAL MODE PROPAGATION IN THREE LAYERED LIQUID HALF-SPACE BY RAY THEORY*

CHARLES B. OFFICER, JR.†

ABSTRACT

The fundamental integral for normal mode propagation in a three liquid layered half-space is derived by multiple reflections, and the physical significance of the characteristic equation is discussed.

Pekeris (1948) has shown how the fundamental integral for two liquid layer normal mode propagation can be derived by ray theory. Press and Ewing (1948) have discussed the physical significance of normal mode propagation in the two layered case. It is the purpose of this paper to derive the fundamental integral and discuss the physical significance of normal mode propagation in the three layered case.

A spherical wave may be represented by the following integral (Sommerfeld, 1949):

$$e^{-i(w/c)R}/R = \int_0^\infty (J_0(kr)\,k\,dk/i\beta)e^{-i\beta(d-z)} \qquad (1)$$

where

$$R=\sqrt{r^2+(d-z)^2}$$

$$\beta=\sqrt{w^2/c^2-k^2}, \quad k<w/c$$

$$=-i\sqrt{w^2/c^2-k^2}, \quad k>w/c$$

w = circular frequency of the source

c = velocity of sound propagation

r = horizontal range

and

d = depth of the source

z = depth of the receiver.

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The integral merely represents the manner in which spherical source is built up from the summation of plane wave about a point. k represents the wave number of the plane wave as measured along the horizontal surface, and β represents the wave number as measured along the vertical. The summation is taken over real and imaginary angles of incidence. For a reflected wave, see Figure 1, the integral becomes

$$\int_0^\infty (J_0(kr)\,kdk/i\cdot\beta)Ke^{-i\beta(d+z)} \tag{2}$$

where K is the plane wave reflection coefficient. The discussion of integrals of this type generalized to an impulsive point source has been carried out by Pekeris (1948) and by Arons and Yennie (1950).

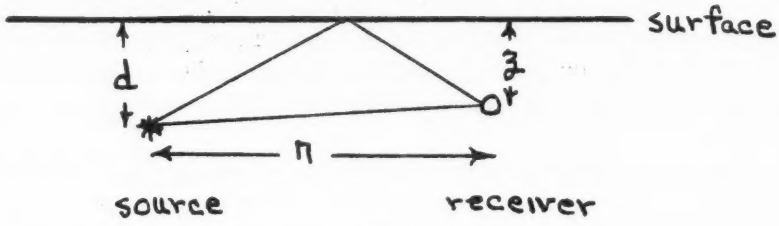
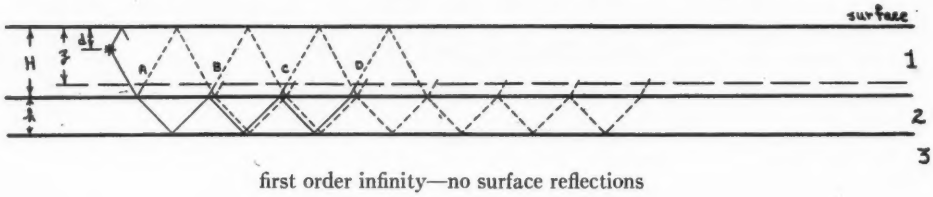


FIG. 1

The fundamental integral for the propagation in a three layered medium is obtained by the generalization to a point source of the summation of multiple reflections from a plane wave source. A plane wave source consists of two sets of outgoing waves—one upgoing and the other downgoing and both at the same angle of incidence with the horizontal. In the resulting integrals, equations (1) and (2), the radial function is the same for all rays so that one needs to consider



first order infinity—no surface reflections

second order infinity—one surface reflection

down going ray up going ray

$$\begin{aligned}
&[e^{-i\beta_1(z-d)} - e^{-i\beta_1(z+d)}] \\
&\quad\times [1 + e^{-i2\beta_1(H-z)}\{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots\}] \\
&\quad\times [1 - e^{-i2\beta_1 H}K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots\} \\
&\qquad + e^{-i4\beta_1 H}\{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + \cdots\} \\
&\quad\times \{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + \cdots\} - \cdots].
\end{aligned} \tag{3}$$

FIG. 2

only the summation of the z-functions of the multiple reflections. This sum is given by equation (3), see Figure 2, where

K = reflection coefficient from medium 1 to medium 2

K' = reflection coefficient from medium 2 to medium 1

L = reflection coefficient from medium 2 to medium 3

and

TT = product of the refraction coefficient from medium 1 to medium 2 and the refraction coefficient from medium 2 to medium 1.

The expression in the first bracket represents the upgoing and downgoing rays from the plane wave source. The minus sign is introduced from the phase change upon reflection at the free surface.

The product of the first expression in the first bracket by the second bracket

$$e^{-i\beta_1(z-d)}\left[1 + e^{-i2\beta_1(H-z)}\left\{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots\right\}\right] \quad (4)$$

is the representation of the effects of the original downgoing ray and the subsequent reflections in the lower medium as measured at the receiver depth. The first term is the original downgoing ray from the source. The second term is the ray reflected from the 1-2 interface. The third term is the ray refracted from 1 to 2, reflected at the 2-3 interface, and refracted back into medium 1. The fourth term represents the ray which has undergone a reflection in the lower medium at the 2-1 interface and then been refracted back into medium 1, and so forth for the other terms. This series of rays is labelled A, B, C, D, in Figure 2 and are indicated by solid lines. A similar interpretation may be given to the product of the second expression in the first bracket by the second bracket.

The products of the above expression by the second term in the third bracket

$$e^{-i\beta_1(z-d)}\left[1 + e^{-i2\beta_1(H-z)}\left\{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots\right\}\right] \quad (5)$$
$$\times e^{-i2\beta_1 H}\left\{K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots\right\}$$

is the expression for the effects of those rays which have undergone one reflection at the free surface. The derivation of this expression can be seen from Figure 2. Each ray in the first bracket, A, B, C, D, $\cdots$, will be reflected from the free surface and then pass through the series of reflections in the second medium, as indicated by the dashed lines in Figure 2, resulting in the product of the two parentheses in expression (5).

The product of expression (4) by the third term in the third bracket represents the effects of those rays which have undergone two reflections from the free surface, and so forth for the other terms in the third bracket finally obtaining expression (3).

In normal mode theory the approximation is made that each finite sum of

multiple reflections can be represented by its appropriate infinite sum. This approximation is now applied to expression (3).

The reflection and refraction coefficients are given by

$$K = (\beta_1 - b\beta_2)/(\beta_1 + b\beta_2) \tag{6}$$

$$K' = (b\beta_2 - \beta_1)/(b\beta_2 + \beta_1) \tag{7}$$

$$L = (\beta_2 - g\beta_3)/(\beta_2 + g\beta_3) \tag{8}$$

$$TT = 4b\beta_1\beta_2/(\beta_1 + b\beta_2)^2 = 1 - K^2 = 1 - K'^2 \tag{9}$$

where

$b = \rho_1/\rho_2$
$g = \rho_2/\rho_3$
$\rho_1 =$ density of medium 1
$\rho_2 =$ density of medium 2
$\rho_3 =$ density of medium 3

Thus, the series in the parentheses of equation (3) becomes

$$\begin{aligned} &K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} + K'^2L^3TTe^{-i6\beta_2 h} + \cdots \\ &\quad = -K' + (L - K^2L)e^{-i2\beta_2 h} + (K'L^2 - K'^3L^2)e^{-i4\beta_2 h} \\ &\qquad + (K'^2L^3 - K'^4L^3)e^{-i6\beta_2 h} + \cdots \\ &\quad = (-K' + Le^{-i2\beta_2 h})(1 + K'Le^{-i2\beta_2 h} \\ &\qquad\qquad + K'^2L^2e^{-i4\beta_2 h} + K'^3L^3e^{-i6\beta_2 h} + \cdots) \\ &\quad = \frac{-K' + Le^{-i2\beta_2 h}}{1 - K'Le^{-i2\beta_2 h}} = \frac{K + Le^{-i2\beta_2 h}}{1 + KLe^{-i2\beta_2 h}}. \end{aligned} \tag{10}$$

And substituting equations (6), (7), (8) and (9) into (10), one obtains

$$(K + Le^{-i2\beta_2 h})/(1 + KLe^{-i2\beta_2 h}) = (R\beta_1 - b\beta_2)/(R\beta_1 + b\beta_2)$$

where $R = 1(+Le^{-i2\beta_2 h})/(1 - Le^{-i2\beta_2 h})$. The third bracket is a geometric series in powers of $[(-R\beta_1 - b\beta_2)/(R\beta_1 + b\beta_2)]e^{-i2\beta_1 h}$ so that expression (3) will be given by

$$\begin{aligned} &[e^{-i\beta_1(z-d)} - e^{-i\beta_1(z+d)}]\,\frac{1 + [(R\beta_1 - b\beta_2)/(R\beta_1 + b\beta_2)]e^{-i2\beta_1(H-z)}}{1 + [(R\beta_1 - b\beta_2)/(R\beta_1 + b\beta_2)]e^{-i2\beta_1 H}} \\ &\quad = 2i \sin \beta_1 d e^{-i\beta_1 z}\,\frac{(R\beta_1 + b\beta_2) + (R\beta_1 - b\beta_2)e^{-i2\beta_1(H-z)}}{(R\beta_1 + b\beta_2) + (R\beta_1 - b\beta_2)e^{-i2\beta_1 H}} \\ &\quad = 2i \sin \beta_1 d\,\frac{R\beta_1 \cos \beta_1(H - z) + ib\beta_2 \sin \beta_1(H - z)}{R\beta_1 \cos \beta_1 H + ib\beta_2 \sin \beta_1 H}. \end{aligned} \tag{11}$$

The integral representation for the field produced by a point source of constant frequency will then be

$$\phi = 2\int_0^\infty J_0(kr)\,kdk\,\frac{R\beta_1\cos\beta_1(H-z)+ib\beta_2\sin\beta_1(H-z)}{R\beta_1\cos\beta_1 H+ib\beta_2\sin\beta_1 H} \qquad (12)$$

which agrees with the expression derived formally by Pekeris (1948) as R can be written in the form,

$$R = i(g\beta_3\tan\beta_2 h - i\beta_2)/(g\beta_3 + i\beta_2\tan\beta_2 h.)$$

This expression may then be generalized by a Fourier transform to an arbitrary point source (Pekeris, 1948).

In the formal solution of the integral (12) the normal modes occur at the poles of the integrand. The equation determining these poles is the dispersion equation for the phase velocity and is called the characteristic equation of the normal mode

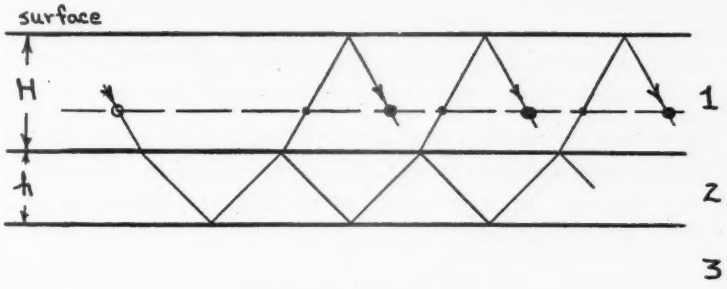


FIG. 3

system. The physical significance of the characteristic equation for the two layered system has been discussed by Press and Ewing (1948). The significance of the three layered equation is discussed here.

The poles of the integrand occur at solutions of the equation,

$$\begin{aligned} R\beta_1\cos\beta_1 H + ib\beta_2\sin\beta_1 H &= 1 + [(R\beta_1 - b\beta_2)/(R\beta_1 + b\beta_2)]e^{-i2\beta_1 H} \\ &= 1 + (K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} \\ &\quad + K'^2L^3TTe^{-i6\beta_2 h} + \cdots)e^{-i2\beta_1 H} \qquad (13) \end{aligned}$$

or

$$\begin{aligned} 1 = -(K + LTTe^{-i2\beta_2 h} + K'L^2TTe^{-i4\beta_2 h} \\ + K'^2L^3TTe^{-i6\beta_2 h} + \cdots)e^{-i2\beta_1 H}. \qquad (14) \end{aligned}$$

This equation states that the normal modes occur when the primary ray is in phase with the sum of the secondary rays suffering one reflection from the free surface. The ray pattern for the first mode as described by equation (13) is indicated in Figure 3.

In the two layered case the condition was that the reflected ray be in phase with primary ray, see Figure 4. In the three layered case the effect of the partial refraction at the first interface must be included.

The higher modes occur at increasing values of k corresponding to multiples of 2π in the phase. The ray patterns for these modes will be similar to Figure 3. The cut off frequency occurs when the sum of the amplitudes of the secondary rays does not equal unity, i.e., when there is partial refraction into medium 3. At the upper end of the spectrum a frequency is passed beyond which the propagation takes place solely in the first layer. This corresponds to critical reflection at the 1-2 interface.

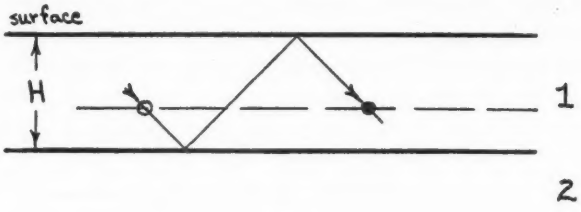


FIG. 4

It is hoped that the method of multiple reflections used here for the interpretation of normal modes in the three liquid layer case can be utilized to obtain the characteristic equation for more complicated problems which, as yet, have not been solved by formal methods.

ACKNOWLEDGMENTS

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BIBLIOGRAPHY

Arons, A., and Yennie, D., *Jour. Acoust. Soc.*, 22 (1950) 231–237.
Perkeris, C., *Geol. Soc. of Amer. Mem.* 27 (1948).
Press, F., and Ewing, M., *Trans. Amer. Geoph. Union*, 29 (1948) 163–174.
Sommerfeld, A., *Partial Differential Equations*, Academic Press, (1949) pp. 240–242.

TRANSIENT ELECTROMAGNETIC PROPAGATION IN A CONDUCTING MEDIUM*

JAMES R. WAIT†

ABSTRACT

The transient electric fields will be calculated for several types of step function current sources embedded in a conducting medium. These will be developed by the aid of the Laplace Transformation. The types of source elements considered are the electric dipole, the magnetic dipole and the linear grounded current element of finite and infinite length.

THE ELECTRIC DIPOLE

Maxwell's Equations in a homogeneous, isotropic, medium characterized by a conductivity σ, dielectric constant ϵ and magnetic permeability μ are:

$$\text{curl } E = -\mu \frac{\partial H}{\partial t} \tag{1}$$

$$\text{curl } H = \left(\sigma + \epsilon \frac{\partial}{\partial t}\right) E \tag{2}$$

where E and H are the vector electric and magnetic field intensities respectively, J is the impressed current density.

The Laplace Transform of these equations are taken yielding:

$$\text{curl } e(s) = -\mu s h(s) \tag{1a}$$

$$\text{curl } h(s) = (\sigma + \epsilon s) e(s) + j(s) \tag{2a}$$

where the quantities $v(s)$ in small letters are the Laplace Transforms of the quantities $V(t)$ in large letters. They are related by the Laplace Integral:

$$v(s) = \int_0^\infty V(t) e^{-st} dt \tag{3}$$

The Laplace Transform of the vector Hertz potential $\Pi(t)$ is denoted by $\pi(s)$ and satisfies the following equation

$$[\nabla^2 - (\epsilon\mu s^2 + \sigma\mu s)]\pi(s) = -j(s)/\mu(\sigma + \epsilon s). \tag{4}$$

It is related to the transform of the field intensities by:

$$e(s) = \text{grad div } \pi(s) - (\sigma\mu s + \epsilon\mu s^2)\pi(s) \tag{5}$$

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and

$$h(s) = 1/(\sigma + \epsilon s) \text{ curl } \pi(s). \tag{6}$$

The solution of equation (4) is well known when the quantities vary as $\exp(i\omega t)$ (Stratton, 1941) and by similar reasoning the following is a solution for $\pi(s)$ whose inverse $\Pi(t)$ gives an outgoing wave at infinity.

$$\pi(s) = \frac{1}{4\pi}\int \mu s j(s)/\gamma^2 r \exp(-\gamma r) dv \tag{7}$$

where $\pi(s)$ is evaluated at the point x, y, z and the integration is performed over x', y', z' space then

$$r = [(x - x')^2 + (y - y')^2 + (z - z')^2]^{1/2}$$

and

$$\gamma^2 = \sigma\mu s + \epsilon\mu s^2.$$

The expression for $\pi(s)$ can be easily found for an infinitesimal electric dipole, of length ds, carrying a current $I(t)$ whose Laplace Transform is $i(s)$. The dipole will be oriented in the z direction and is at the origin of the coordinate system. The x', y', z' space in this case is simply the volume of the dipole so that it follows that:

$$\pi(s) = \pi_z(s) = i(s)dS/4\pi(\sigma + \epsilon s) \exp(-\gamma r)/r \tag{8}$$

and

$$\pi_x = \pi_y = 0.$$

The transform of the field components are then obtained by using equations (5), (6), and (8). The inversion of the resulting transform apparently is not easily found and they involve the unit impulse and doublet impulse functions. For this analysis a great simplification can be made at the outset if the displacement currents are neglected. That is, the operator $(\sigma+\epsilon\partial/\partial t)$ in (1) is replaced by σ. When the fields vary as $\exp(i\omega t)$ this means that $(\sigma+\epsilon\omega)$ is replaced by σ which is valid for frequencies $\omega \ll \sigma/\epsilon$. When the source is of a step function type this means the predicted transient response is valid for times $t \gg \epsilon/\sigma$. Then $\sigma+\epsilon s$ is replaced by σ in the above expressions for the transforms.

With this simplification and using (5), (6), and (8) the Laplace Transforms of the field expressions are given by:

$$e_r(s) = i(s)dS/2\pi\sigma r^3(1 + \alpha s^{1/2})[\exp(-\alpha s^{1/2})] \cos\theta \tag{9}$$

$$e_\theta(s) = i(s)dS/4\pi r^3)(1 + \alpha s^{1/2} + \alpha^2 s)[\exp(-\alpha s^{1/2})] \sin\theta \tag{10}$$

and

$$h_\phi(s) = i(s)dS/4\pi r^2(1 + \alpha s^{1/2})[\exp(-\alpha s^{1/2})] \sin\theta \tag{11}$$

where

$$\alpha^2 = \sigma\mu r^2.$$

A step function current source will be considered of the form:

$$I(t) = Iu(t)$$

where

$$u(t) = 1 \quad \text{for times} \quad t > 0$$

and

$$u(t) = 0 \quad \text{for times} \quad t < 0.$$

Now

$$L[Iu(t)] = I/s \tag{12}$$

where L is the symbol which states that the Laplace Transform of $Iu(t)$ is equal to I/s.

A well known transform (Churchill, 1944, Transform #83) is given by:

$$\exp(-\alpha s^{1/2})/s = L(1 - \operatorname{erf} \alpha/2t^{1/2})u(t) \tag{13}$$

where $\operatorname{erf}(x)$ is the error function of argument x (Jahnke & Emde, 1944).

The other necessary transforms can be obtained by a first and second differentiation of equation (13) with respect to α yielding:

$$\alpha \exp(-\alpha s^{1/2})/s^{1/2} = L[\alpha/2t^{1/2} \operatorname{erf}'(\alpha/2t^{1/2})] \tag{14}$$

and

$$\alpha^2 \exp(-\alpha s^{1/2}) = L[2(\alpha/2t^{1/2})^3 \operatorname{erf}'(\alpha/2t^{1/2})]. \tag{15}$$

Using these relations the inversion of the transforms (9), (10), and (11) can be carried out readily to give the expressions for the field intensities for a step function current source.

$$E_r(t) = IdS/2\pi\sigma r^3 \cos\theta A(t)u(t) \tag{16}$$

$$E_\theta(t) = IdS/4\pi\sigma r^3 \sin\theta B(t)u(t) \tag{17}$$

and

$$H_\phi(t) = IdS/4\pi r^2 \sin\theta A(t)u(t) \tag{18}$$

where

$$A(t) = 1 - \operatorname{erf}(\alpha/2t^{1/2}) + \alpha/2t^{1/2} \operatorname{erf}'(\alpha/2t^{1/2}) \tag{19}$$

$$B(t) = 1 - \operatorname{erf} \alpha/2t^{1/2} + [\alpha/2t^{1/2} + 2(\alpha/2t^{1/2})] \operatorname{erf}'(\alpha/2t^{1/2}) \tag{20}$$

where

$$\operatorname{erf}'(x) = d/dx \operatorname{erf}(x).$$

The functions $A(t)$ and $B(t)$ indicate how the fields build up with time to their static value. These functions are plotted in Figure 2. It is seen that for large values of time $A(t)$ and $B(t)$ approach unity. The function $B(t)$ rises to a maxi-

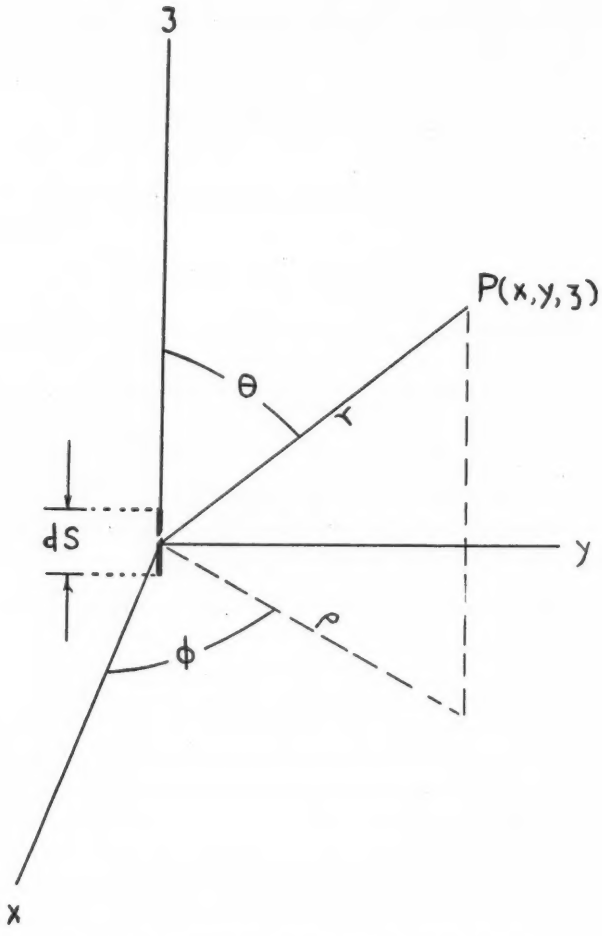

FIG. 1. The coordinate system for the dipole source.

mum value of 1.42 when $\alpha/2t^{1/2}=1$. The value corresponding to the maximum point is given by:

$$t = t_m = \alpha^2/4 = \sigma\mu r^2/4.$$

The velocity of the maximum point of the waveform is then:

$$v_m = dr/dt = 2/\sigma\mu r.$$

This infers that the maximum point of the E_θ response for a step function current

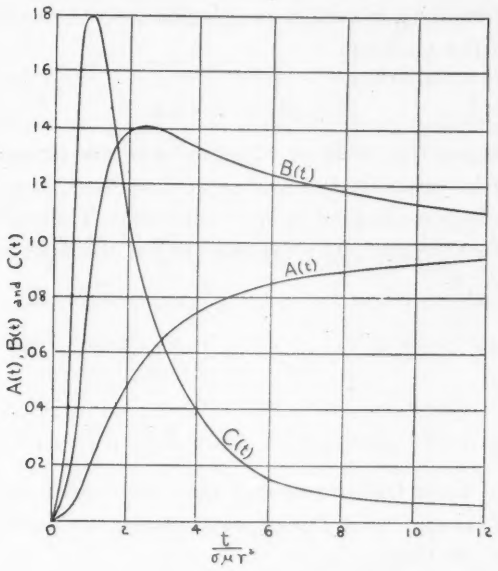

FIG. 2a. The transient field responses plotted versus the time parameter for a step function dipole source.

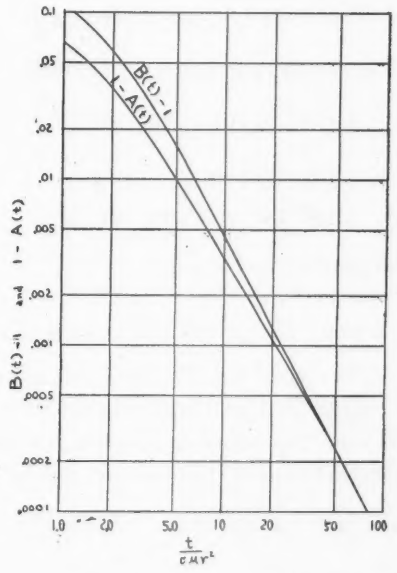

FIG. 2b. The transient field responses plotted versus the time parameter for large values of the latter.

source has a radial velocity inversely proportional to the radial distance and to the conductivity of the medium.

MAGNETIC DIPOLE

In a similar manner the fields of a magnetic dipole or small loop of current $I(t)$ of area dA can be calculated:

The axis of the loop is oriented in the z direction. These fields can be derived from a magnetic Hertz vector. The expressions for the field transforms are:

$$h_r(s) = i(s)dA \cos\theta/2\pi r^3(1 + \alpha s^{1/2})[\exp(-\alpha s^{1/2})] \tag{21}$$

$$h_\theta(s) = i(s)dA \sin\theta/4\pi r^3(1 + \alpha s^{1/2} + \alpha^2 s)[\exp(-\alpha s^{1/2})] \tag{22}$$

and

$$e_\phi(s) = -\mu s i(s)dA \sin\theta/4\pi r^2(1 + \alpha s^{1/2})[\exp(-\alpha s^{1/2})]. \tag{23}$$

The inversion of these transforms can again be readily carried out by means of equations (13), (14) and (15). The expressions for the fields for a step function current loop source are then:

$$H_r(t) = dAI/2\pi r^3 \cos\theta A(t)u(t) \tag{24}$$

$$H_\theta(t) = dAI/4\pi r^3 \sin\theta B(t)u(t) \tag{25}$$

and

$$\begin{aligned} E_\phi(t) &= -\mu dAI/4\pi r^2 \sin\theta(d/dt)A(t)u(t) \\ &= -IdA/2\pi\sigma r^4 \sin\theta C(t)u(t) \end{aligned} \tag{26}$$

where $A(t)$ and $B(t)$ are given in (19) and (20) and $C(t)$ is given by:

$$C(t) = (\alpha/2t^{1/2})^4 \operatorname{erf}''(\alpha/2t^{1/2}) \tag{27}$$

where

$$\operatorname{erf}''(x) = d^2/dx^2 \operatorname{erf}(x)$$

The function $C(t)$ is also plotted in Figure 2.

THE FIELD OF A FINITE CURRENT ELEMENT

An expression will be developed for the transient fields due to a step function of current in a wire of length B-A embedded in an infinite medium of conductivity σ and permeability μ. The coordinate system is shown in Figure 3. The fields at the point $P(\rho, z)$ due to a current $i(s)$ at the point (o, S) is:

$$e_z(s)/i(s) = dS[P(r) + (\partial^2/\partial S\partial z)Q(r)] \tag{28}$$

and

$$e_\rho(s)/i(s) = dS[\partial^2 Q(r)/\partial S\partial\rho] \tag{29}$$

where,

$$P(r) = \mu s \exp(-\gamma r)/4\pi r \quad \text{and} \quad Q(r) = \exp(-\gamma r)/4\pi\sigma r.$$

This follows from equations (5) and (6) where here cylindrical coordinates are used. The expressions for the field transforms at P due to current transform $i(s)$ throughout the length of the wire is given by:

$$e_z(s)/i(s) = \int_A^B \left[P(r)dS + (\partial/\partial z)Q(r) \right]_{s=A}^B. \tag{28a}$$

and

$$e_\rho(s)/i(s) = \left[(\partial/\partial_\rho)Q(r) \right]_{s=A}^B. \tag{29a}$$

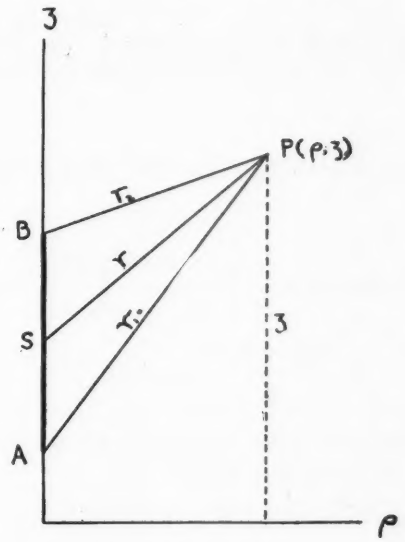

FIG. 3. The coordinate system for the finite current element extending from A to B.

The current in the wire will be assumed to be constant throughout its length and is of a step function type:

$$i(s) = L[Iu(t)] = I/s.$$

Then

$$e_z(s)/I = \mu/4\pi \int_A^B \left[\exp\left[-(\sigma\mu s)^{1/2}r\right]/r dS + \partial/\partial z \exp\left[-(\sigma\mu s)^{1/2}r\right]/r \right]_{s=A}^B$$

and

$$e_\rho(s)/I = \left[\partial/\partial\rho \exp\left[-(\sigma\mu s)^{1/2}r\right]/r \right]_{s=A}^B.$$

The expressions for the fields using equation (13) are after inversion:

$$E_z(t) = \mu/4\pi \int_A^B 1/2(\sigma\mu/\pi t^3)^{1/2} \exp(-\sigma\mu r^2/4t)dS + (\partial/\partial z)\left[1 - \operatorname{erf}\left[\frac{r}{2}\left(\frac{\sigma\mu}{t}\right)^{1/2}\right]/r\right]_{z=A}^{B} \tag{30}$$

and

$$E_\rho(t) = (\partial/\partial\rho)\left[1 - \operatorname{erf}\left[\frac{r}{2}\left(\frac{\sigma\mu}{t}\right)^{1/2}\right]/r\right]_{z=A}^{B}. \tag{31}$$

The integral in the above expression will be evaluated

$$\int_A^B \exp(-\sigma\mu r^2/4t)dS = \exp(-\beta^2\rho^2)\int_A^B \exp[-\beta^2(s-z)^2]dS$$

where

$$r^2 = \rho^2 + (S-z)^2 \quad \text{and} \quad \beta^2 = \sigma\mu/4t.$$

Then

$$\int_A^B \exp(-\beta^2 r^2)dS = \frac{\exp(-\beta^2\rho^2)}{\beta}\int_{\beta(A-z)}^{\beta(B-z)} \exp(-x^2)dx$$
$$= \frac{\exp(-\beta^2\rho^2)}{\beta}[\operatorname{erf}[\beta(\beta - z)] - \operatorname{erf}[\beta(A-z)]].$$

Using the above relation and carrying out the differentiations in equation (30) and (31) the complete expressions become:

$$E_z(t) = \mu/4\pi t(1/\pi)^{1/2}\exp(-\beta^2\rho^2)\{\operatorname{erf}[\beta(B-z)] - \operatorname{erf}[\beta(A-z)] + 1/4\pi\sigma[M(r_1) - M(r_2)] \tag{32}$$

and

$$E_\rho(t) = 1/4\pi\sigma[N(r_1) - N(r_2)] \tag{33}$$

where

$$M(r) = (z-S)/r^3[1 - \operatorname{erf}(\beta r) + \beta r \operatorname{erf}''(\beta r)],$$
$$N(r) = \rho/r^3[1 = \operatorname{erf}(\beta r) + \beta r \operatorname{erf}''(\beta r)],$$
$$r_1 = [(A-z)^2 + \rho^2]^{1/2},$$

and

$$r_2 = [(B-z)^2 + \rho^2]^{1/2}.$$

The physical counterpart of this case could be a linear insulated wire which is

grounded at its end points. The step function current generator is anywhere between its end points. The assumption that the current is constant throughout its length implies that the propagation constant is negligibly small for important times in the transient response. This is certainly the case for most types of insulation where the shunt admittance is relatively small.

It can also be shown that the insulation has negligible effect on the radiation from the wire into the conducting medium as long as the over-all radius R_0 of the insulated wire is such that $R_0 \ll (2t/\sigma\mu)^{1/2}$ where σ and μ are the properties of the external medium and t is the time that the transient is measured following the application of the step function current. This follows from the fact that the radial wave impedance at the insulation medium boundary is almost identical for the insulation material and conducting medium when R_0 satisfies the above inequality.

An interesting check on the above method is to find the expression for the fields when the source wire is infinite. When $-A$ and $+B$ go to infinity the fields become

$$\begin{aligned} E_z(t) &= \mu/\propto \pi(\sigma\mu/\pi t^3)^{1/2} \exp(-\beta^2\rho^2) \int_{-\infty}^{+\infty} \exp(-\beta x^2)dx \\ &= \mu/4\pi t \exp(-\beta^2\rho \end{aligned} \tag{34}$$

and

$$E_\rho(t) = 0.$$

Now

$$L(E_z(t)/I) = \mu s/4\pi[K_0[(\sigma\mu s)^{1/2}\rho]]$$

using transform No. 117 (Churchill, 1944). Then it follows that

$$e_z(s)/i(s) = (\mu/2\pi)K_0[(\sigma\mu s)^{1/2}\rho].$$

If the current is of the form $I \exp(i\omega t)$ then the field is

$$e_z(i\omega) \exp(i\omega t)/I = (\mu/2\pi)K_0[(i\sigma\mu\omega)^{1/2}\rho] \exp(i\omega t). \tag{35}$$

This expression checks with Carson (1929, p. 94).

BIBLIOGRAPHY

Carson, J. R., *Bell System Technical Journal*, Vol. VIII, January 1929.
Churchill, R. V., *Modern Operational Mathematics*, McGraw-Hill (1944).
Jahnke, E., and Emde, R., *Tables of Functions*, Dover (1944).
Stratton, J. A., *Electromagnetic Theory*, McGraw-Hill (1941).

GRAPHIC ADJUSTMENT BY LEAST SQUARES*

A. E. SMITH†

The gravity meter in use today measures the differences in the acceleration of gravity between stations. When three or more gravity stations are interconnected by measured differences to form closed gravity station networks, values for the accelerations of gravity at all stations must be derived in such a manner that around all closed circuits the algebraic sum of the adjusted gravity differences is zero. Since the errors involved are assumed to be random, a solution can be obtained by the method of "least squares." However, for large networks, the usual least squares solution is so time-consuming that it is frequently omitted in cases where its application would be desirable. It is the purpose of this paper to describe the practical application of a more speedy method.

In a paper by Gibson (1941), it is shown that the least square solution was achieved when the two following conditions were met:

1) The algebraic sum of the corrected differences around any circuit is zero.
2) The sum of the weighted corrections at any junction is zero.

For the closed circuit ABC in Figure 1, condition 1 states that:

$$(D_{23} + K_{23}) + (D_{24} + K_{24}) + \cdots + (D_{12} + K_{12}) = 0. \tag{1}$$

The error of this circuit has been found by:

$$D_{23} + D_{24} + \cdots + D_{12} = E_2. \tag{2}$$

Subtracting equation 2 from equation 1:

$$K_{23} + K_{24} + \cdots + K_{12} = -E_2. \tag{3}$$

The signs in equations (1), (2), and (3) are positive when the increase is in a counter-clockwise direction around the closed circuit and negative when clockwise.

For the junction at A in Figure 1 condition 2 states that:

$$\frac{K_{12}}{a_{12}} + \frac{K_{23}}{a_{23}} + \frac{K_{35}}{a_{35}} + \cdots + \frac{K_{n1}}{a_{n1}} = 0. \tag{4}$$

In equation (4) "a" is the adjustability or the reciprocal of the weight assigned to each observed difference, the signs being positive when the increase in numerical value is towards the junction and negative when away.

In any unadjusted network condition 2 is fulfilled at the start, since all corrections are zero. If this condition can be maintained as the solution develops, the

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manipulation will be simplified. Maintaining this condition for each junction is done by adding two equal corrections, one positive and one negative, whenever an adjustment is made. Thus in correcting completely around a closed circuit equal corrections made in the same direction to every side will provide equal positive and negative corrections at every junction of that circuit.

From equation (3) condition 1 is satisfied when the sum of the corrections around a closed circuit equals the error of the circuit with the sign reversed. Therefore, to effect a least squares solution, it is only necessary to fulfil this requirement while keeping the junction corrections at zero. This is done by laying out a schematic representation of the network on a convenient scale showing the measured differences between each pair of stations, the error of closure for each

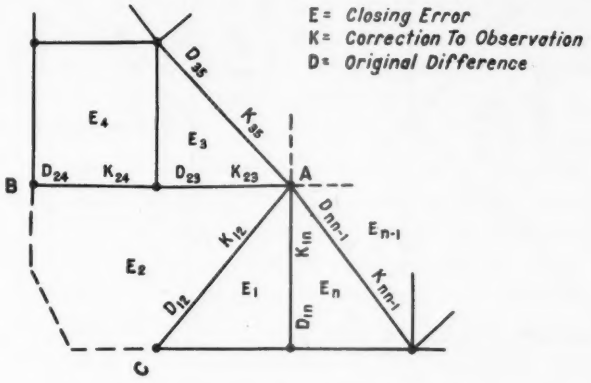

FIG. 1. Details of circuits and junctions.

circuit and the direction of the error as derived from equation (2). The best arrangement of this schematic diagram will be found by experience, but a few general suggestions may be offered. It is found best to eliminate as much as possible the ties which cross over each other and to group together the errors in one direction. If several fixed values are present in the network, the ties that join them are used as the outside of the network but where there are no fixed values, or only one, any station may be selected and a fixed side drawn from it surrounding the network and returning to the station; the difference along this line is, of course, zero. An outside tie of fixed value (or zero) is necessary as within the outside loop thus formed the sum of all closing errors is zero at all times. This provides another method of checking for mistakes as the solution progresses since it is usually the case that if the closing errors add to zero no mistake has been made and, therefore, the junction corrections will equal zero.

The small network in Figure 2 will be used as an example of the procedure in an actual "graphic solution." The term "graphic" has attached itself to this method because all calculations are done in pencil on the network diagram and there are no other sheets of equations or figures necessary. The network is laid

out and the error with the direction of the error for each circuit is shown within the circuit. The number under the error is the sum of the "adjustabilities" of the sides of the circuit or, in this case, the number of sides since one unit weight has been assigned to each tie. In laying out an actual network the observed differences between stations will probably also be recorded. The circuits in the example

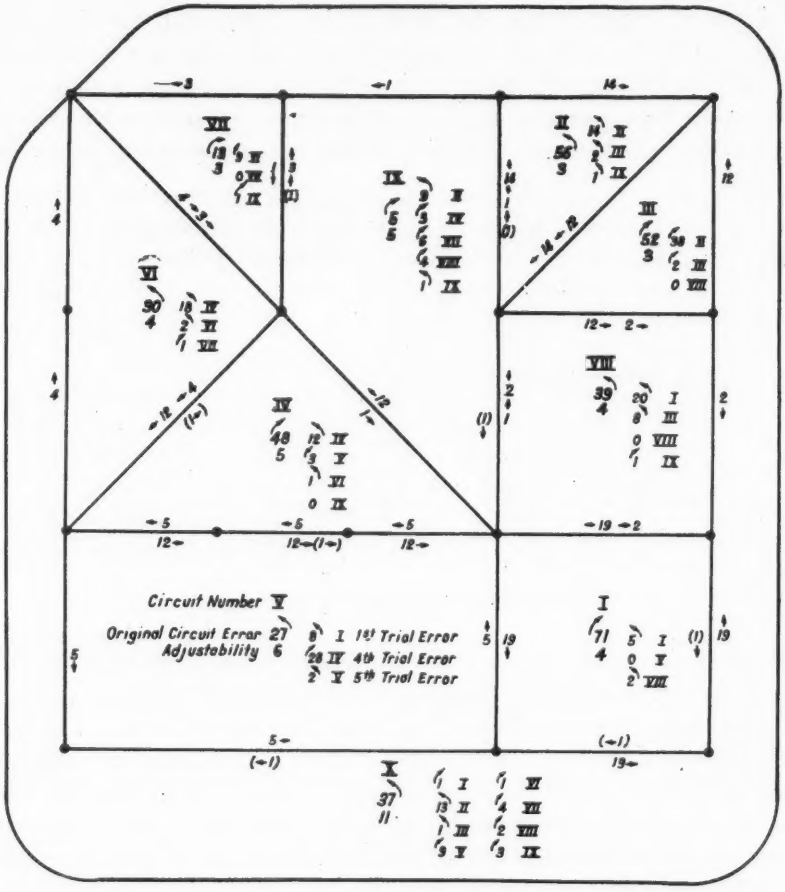

FIG. 2. Small network showing steps used in the adjustment of errors.

are numbered by Roman numerals simply for convenience in describing the operations; this is not necessary in the actual solution. The above data can best be recorded in ink, on a good grade of paper; the rest of the operation, which is subject to quite a bit of erasing, may well be carried out in pencil.

Selecting the first circuit to be adjusted is arbitrary but that having the largest error is usually preferred which in this case is circuit I. This circuit has a clockwise error of 71 and an adjustability of 4. Dividing the error by the ad-

justability, the closest whole number is found to be 18 and the closest round number 20; either of these would be a good value to use for the first error correction which is always subject to later revision. In order to prevent a large accumulation of figures due to the oscillation of errors the final values are used throughout this example. It should be understood, however, that in actual computation a trial and error method is used and the figures are revised several times. The value of 19 is the correction used for each side of circuit *I* and is recorded alongside each of the four sides in light pencil with an arrow, dot, or other suitable symbol to show the direction of the correction. This is a total correction to the circuit of 76, and an overcorrection of 5. A counter-clockwise error of 5 remains which is shown in pencil alongside the original closure error. It is the judicious use of under or over correction of one circuit taken in relation to the other circuits that gives the graphic solution its speed. The errors of closure of the adjacent circuits are affected by this adjustment and new values written in pencil. Circuit VIII is changed from 39 counter-clockwise by 19, which in this circuit is in a clockwise direction, resulting in a closure error of 20 counter-clockwise. The error of circuit V is changed from 27 counter-clockwise to 8 counter-clockwise. The error of the outside circuit *X*, which is affected by 2 ties is changed by twice 19, one for each tie, to an error of 1 in a clockwise direction. The second highest error of closure will be taken next, although again this is not necessary, as any circuit or combination of circuits could be selected. The selection of several circuits in combination, especially those having the same direction of closing error, and the correcting of the outside ties of the combined circuits as though the combination was one single circuit, frequently offers an advantage. The counter-clockwise error in circuit II totals 56 and the circuit has an adjustability of 3: a value around 20 could be tried as an approximation, but again for simplicity the more nearly correct undercorrection of 14 clockwise is used in the example, reducing the closing error to 14 counter-clockwise and the errors of closure in the three adjacent circuits are each accordingly changed by 14 counter-clockwise. The adjacent circuit III, with an original clockwise error 52, now has a remaining error of 38 which is distributed as 12 to each side. Continuing in a like manner, in the order of the circuit numbers designated by Roman numerals, each circuit is reduced and the effect of the reduction on the correction of the adjacent circuits is shown by a small Roman numeral beside the adjusted closure error. In practice, as a new closure error is determined and recorded, the preceding error is erased.

The closing error for each circuit is finally reduced to half or less than half of the adjustability for that circuit and the final check on the sum of the closure errors and the corrections at the junctions is made. The closure errors in the example have been reduced from 189 to 6 in a clockwise direction and from 189 to 6 in a counter-clockwise direction. The junction in the upper left hand corner of circuit I, shows the corrections of 19, 2, 5, 12, and 1, a total of 39 made in the direction towards the junction and 19, 5, 12, 2, and 1, a total of 39 in the direc-

tion away from the junction. The values are usually erased and reduced to one value for each tie whenever a check of the sum of the errors is made as in actual practice there will be quite a number of figures on some of the ties. Each junction is checked to determine if the corrections towards and away from it are equal. If this is not the case, adjustments are made to the ties which will make the corrections at each junction equal zero and the revised closing errors are again reduced to their minimum. When there is more than one fixed value in the outside circuit the total corrections toward all such fixed points, which are in effect one single junction, must equal the total corrections away from all such points.

The small errors of closure must now be eliminated since in measuring around each circuit the error must be zero. The small errors, which are the limits of any least squares adjustment, are spread between the circuits in the most convenient manner so that they cancel each other. In Figure 2 these corrections are in parenthesis. This transfers the small errors of closure to small errors in the junction where they are allowed to remain. The adjustments are then added alge-

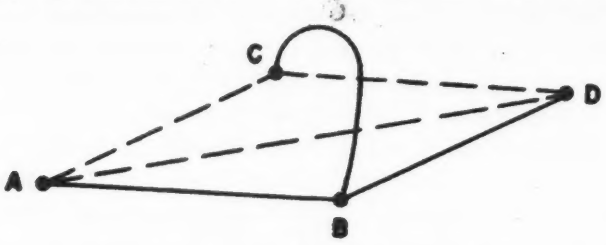

FIG. 3. Illustration of "third dimension tie."

braically to the observed gravity differences. The results are the same as would be obtained from the most laborious least squares solution.

Instead of using junctions in which there are only two ties the results can be obtained by combining them and revising the adjustability; for example, the ties common to circuits IV and V can be combined to one tie with an adjustability of 3. In adjusting gravity networks it is desired frequently to give various weights to each measured difference dependent upon the time which elapsed during the making of the observations; thus the minutes which elapsed between taking readings in the field could be used as the adjustability. When using weighted values it is better to use only corrections which are multiples of the adjustability as this results in whole numbers for the junction adjustments when the total adjustment is divided by the adjustability thereby simplifying the junction check.

When ties cross over each other without a common junction they should be eliminated, if at all possible, by revising the position of the stations on the network. These ties have been called "jump ties" by Gibson, but in the graphic solution the custom has been to call them "third dimension" ties as a more descriptive term. In a four-sided circuit *A-B-C-D* of Figure 3, the diagonal corners *A-D* and *B-C* are tied but there is no junction where these ties cross. The *A-D*

tie may be visualized in the ordinary horizontal plane and the *B-C* tie as being an arch above the horizontal plane. The circuits *A-B-C* and *B-D-C* therefore, form a three dimensional figure. These third dimension circuits are fitted into the network in a similar manner to the other circuits except that the corrections on each common side affect three circuits instead of two. The sum of the closing errors of the third dimension circuits should equal the sum of the closing errors of the corresponding circuits in the network. The closing errors of *A-B-C* plus the closing error of *B-C-D* equals the closing error of *A-C-D* plus the closing error of *A-B-D*. No difficulty is involved in the junction adjustment as all corrections are added together at the junctions.

The graphic method was developed primarily for the adjustment of gravimetric results but lends itself readily to the adjustments of all data that can be diagrammed as closed circuits.

From the laying out of the network to the last zero closure the progress of the solution is always in full view and can be stopped anywhere with no time lost in picking up again at a later date. New data can be added within or adjacent to a network at any time during the adjustment with a minimum of effort. No direct comparison of the time advantage of the graphic method over the algebraic method of least squares has been made, but from experience in both methods the ratio of the time relationship would be about as hours are to days. The person who enjoys crossword puzzles, solitaire, chess problems, etc., will readily look on this method as being in the same category and not relegate it to the realm of normal equations and correlates.

BIBLIOGRAPHY

Gibson, M. O., "Network Adjustment by Least Squares—Alternative Formulation and Solution by Iteration," *Geophysics*, VI (1941) 168–179.

GEOMAGNETIC SURVEY OF A PORTION OF SOUTHEASTERN NEW YORK STATE*

RICHARD A. GEYER†

ABSTRACT

A geomagnetic survey, using an Askania magnetometer, of portions of northern Westchester, Putnam and Dutchess counties in New York state totaling approximately one hundred and thirty square miles is described and more than five hundred observations of the vertical component of the earth's magnetic field are analyzed. These data are plotted on a scale of 1:30,000 and the resulting isogam chart is used to correlate the observed major changes in the vertical component with variations in the geology of an area in which basement complex rocks outcrop.

This survey demonstrates that a rather well defined relationship exists between changes in the vertical component values and the major gelogic characteristics, using an average (regional) station spacing of four stations per square mile. In addition, the probable presence, on the basis of the magnetic data, of additional unexposed amphibolite lenses and associated igneous intrusives is indicated in those areas of the Eastern Schist Zone where the glacial overburden and/or soil obscure the underlying formations. The use of statistical methods is demonstrated for evaluating magnetic data for various purposes including the determination of interformational boundaries and the correlation of pronounced changes in geologic and magnetic characteristics.

INTRODUCTION

The objectives of this geomagnetic survey may be classified into three major categories, namely,

(a) To investigate the possibility of the existence of a correlation between the variations in the vertical component of the earth's magnetic field, ΔZ, and the major geologic characteristics of an area in which basement complex rocks outcrop. Can the observed variations be used to distinguish the different rock types present, and to define their areal distribution in areas where they are overlain by glacial overburden or otherwise obscured?

(b) To determine whether the correlation in (a) can be obtained with a minimum of magnetic observations even in an area characterized by great geologic complexity. Thus are measurements of ΔZ using an average station spacing of about four to a square mile sufficient to outline the major geologic and geophysical characteristics of such an area?

(c) To determine whether statistical methods can be applied successfully in the computation of regional corrections for magnetic data and to evaluate the over-all significance of these data for the purposes of geologic correlation.

Therefore, the area chosen is one in which the formations vary in geologic characteristics from only slightly metamorphosed limestones to highly metamorphosed marbles, schists, a variety of gneisses and igneous intrusives. For the most part they combine rock types that are frequently described by geologists as

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"basement complex." In addition, it is also characterized by the widespread presence of glacial overburden and swamps. Nevertheless, a great deal of geologic information is available. References to this area are found in the literature for a period of more than one hundred years. They begin with papers by Mather (1844) and Dana (1870). The most recent as well as very detailed geologic information is available in papers by Balk (1936) and Barth (1936). These papers form the basis for most of the geologic evidence used in this correlation study. Many of the detailed chemical analyses in the latter paper are especially useful. In fact the existence of these papers together with the previously mentioned suitable geologic characteristics of this area constitute the chief reason why it was chosen for the geomagnetic survey.

The area covers approximately one hundred and thirty square miles of northern Westchester, Putnam and Dutchess counties located in southern New York state. It includes portions of the Clove and Carmel quadrangles of the United States Geological Survey. An Askania magnetometer is used to measure the vertical component of the earth's magnetic field, at four hundred and fifty-three different regional stations, and eighty-six additional ones used in the construction of detailed profiles.

ACKNOWLEDGMENTS

The use of an Askania magnetometer belonging to Dr. George P. Woollard of the Dept. of Geology, University of Wisconsin, together with his very helpful comments from time to time during the course of this work, is very much appreciated. It should be noted that a substantial portion of the field expenses and the entire cost of preparing the thin sections were granted from funds of the Department of Geology, Princeton University. Acknowledgments are also due for assistance in obtaining the field data, during the Fall and Winter of 1941, to my wife, Anne T. Geyer, and B. F. Leonard, III.

GENERAL GEOLOGY

The formations in this area vary in character from only slightly metamorphosed sedimentary rocks to highly altered igneous and sedimentary formations. The metamorphosed types include gneisses, schists and dolomitic marbles, and the igneous intrusives are represented by syenite, diorite and ultrabasic dikes.

The pre-Cambrian basement complex portion of the area also includes a granitoid phase and is a continuation of the pre-Cambrian gneiss of the Highlands. The geologic and magnetic characteristics of the various rock types are summarized in the following paragraphs.

Granitoid Gneiss

The granitoid gneiss is confined to a prong five miles long and averaging two and one-half miles in width in the northwestern portion of the area. It has a well defined northeast-southwest strike. A few of the thin sections show the presence

of a small amount of magnetite. However, a substantial amount of ferromagnesian minerals occurs in many instances. This would seem to indicate that the higher magnetic values measured over the granitoid gneiss may be attributed in part to the presence of these minerals in substantial quantities in addition to appreciable percentages of magnetite.

Syenite

An intrusion of syenite is found in the gneiss zone near the southern boundary of the area. It occurs about five miles south of Pawling and is elliptical in shape having an area of slightly less than one square mile. A small amount of magnetite occurs in the three thin sections made from this rock. The minor magnetic anomaly coinciding with the general outlines of this intrusive may be explained on this basis.

Diorite

An outcrop of diorite occurs about three and one-half miles northeast of Carmel. It can be traced at the surface only for a short distance because of the thick glacial overburden present in this region. However, it is believed on the basis of magnetic and topographic evidence that it has an area of about three and one-half square miles. Koeberlin (1907) refers to the presence of diorite near Croton Falls, which is only a few miles to the south. He believes that it occurs as a laccolith with the central neck of the plug situated at Croton Falls and apophyses extending northward. It is problematical whether or not the outcrop at Carmel is related to the one at Croton Falls, but it is evident that igneous intrusions of this type are present in the general area. Thus they could be responsible for some of the magnetic anomalies observed even though the actual outcrops may be obscured by glacial overburden. Although only a moderate amount of magnetite is found in the thin sections made from this outcrop, they contain large amounts of ferromagnesian minerals. Therefore, the minor magnetic "high" present over this intrusion may be attributed in part to the presence of these minerals as well as that of some magnetite.

Ultrabasic Dikes

A dike outcrops in the immediate vicinity of an abandoned iron ore mine situated southwest of Pine Pond near Carmel. Its strike is approximately north-south and it varies in width from about one to three hundred yards. Newland (1919) in his description of this dike believes it to be an altered peridotite. He bases his opinion primarily on a chemical analysis which indicates that the rock is ultrabasic in composition, a serpentinite.

It is not surprising because of the altered character of this dike that a magnetic traverse across it, as illustrated in Figure 1, yields anomalous values that are only about 600 gammas above the regional. Sufficient magnetite is visible in thin sections to explain adequately the magnitude of the observed anomalies.

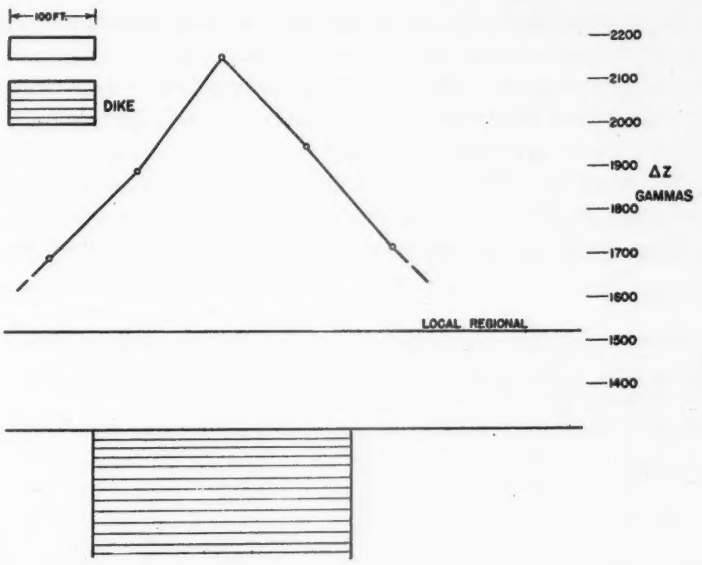


FIG. 1. Magnetic cross section over ultrabasic dike near Carmel, New York.

Gneiss

At least three kinds of gneiss are recognized in this area including granitoid, plagioclase and perthite types. According to Barth's estimate of the quantitative mineral composition of a perthite gneiss specimen this variety of gneiss does not contain any appreciable amount of magnetite. Barth describes a specimen from the junction of the Connecticut-New York border line in the Quaker Brook valley area (1936, p. 812). The magnetic values in this region of perthite gneiss average about 1,200 gammas. This is the lowest average value for any portion of the entire gneiss zone. These values occur in a zone extending in a nearly north-south direction in the southeastern part of the area, near the location of Barth's perthite gneiss specimen. They extend over an area of approximately five square miles. Barth (1936) also includes an analysis of an augen gneiss appearing in a paper by Fettke (1914, p. 242). The magnetic values in the area from which this specimen is described average about 1,350 gammas. A thin section study of outcrops in this region reveals the absence of an appreciable amount of magnetite.

Thin sections of the gneiss and granitoid gneiss specimens from this area are characterized by the fact that some contain small amounts of magnetite whereas in the majority of the cases this mineral is almost entirely absent. However, the comparative minor variations in the amount of magnetite present in these rocks are reflected in the moderate changes measured in the vertical component of the earth's magnetic field over most of these zones of metamorphosed pre-Cambrian rocks. Therefore it is evident that some reasonable correlation can be made between the observed magnetic values and the mineralogic and petrographic char-

acteristics of the associated gneisses for purposes of classification and differentiation. The general relationships are summarized in Table 1.

This table demonstrates that the three principal types of gneiss in this area all exhibit well defined magnetic characteristics. Not only is there a pronounced difference between the average values for each of the three types, but a slight overlap of the magnetic values occurs between the upper limit of one type and the lower of another. These relationships are shown schematically in Figure 2. Thus the three major gneiss types of the area can be differentiated by their

TABLE 1

STATISTICAL ANALYSIS OF MAGNETIC VALUES OBSERVED OVER GNEISS

(Arranged in order of decreasing magnetite and ferromagnesian mineral content on the basis of Barth's chemical analyses and thin section studies made by the author.)

Type of Gneiss	Number of Cases	Average Value (Gammas)	Standard Deviation	Lower Limit	Upper Limit
Granitoid	52	1,720	158	1,560	1,880
Plagioclase	133	1,500	116	1,390	1,610
Perthite	49	1,260	158	1,100	1,420

magnetic characteristics, which are primarily a reflection of the changes in their respective magnetic susceptibilities. The magnetic susceptibilities in turn are dependent upon the mineral content of the individual gneiss type, with special emphasis upon the magnetite and ferromagnesian content.

Brandl (1939) uses a similar approach with reasonable success in differentiating between the various types of igneous rocks in the "Brockenmassif" in Germany. His results are obtained using about the same regional station spacing, namely at kilometer intervals. His investigations also show that the percentage of magnetite is the primary factor in determining the susceptibility of a rock to such an extent that appreciable variations in susceptibility can be attributed essentially to the distribution of the magnetite in the rock. He bases his contention on the fact that no magnetite is visible in thin sections from rocks having a low susceptibility.

Schists

The schist specimens in and near the area of the magnetic survey which Barth (1936) describes do not vary appreciably in their magnetite content. Three representative specimens contain 1.1, 1.2 and 1.4 per cent magnetite respectively. In addition, the regional magnetic values for the two major schist zones only differ by about 50 gammas. The schist in this area may be divided into two zones, namely, that found east of the Harlem Valley limestone zone and that present to the west.

The amount of magnetite present in thin sections of the schists varies from a

small amount to none. Even in cases where magnetite occurs in thin section the amount never exceeds and rarely even equals that occurring in the thin sections of the ultrabasic dike. This is important because it indicates that the very large anomalies existing over the Eastern Schist zone are not caused by an unusually high percentage of magnetite disseminated more or less homogeneously through the formation. This contention is further substantiated by chemical analyses of these rocks available in Barth (1936). It would therefore indicate that the cause of the very large anomalies, which is discussed in more detail later, must be sought for in zones or lenses of rocks within the schist area.

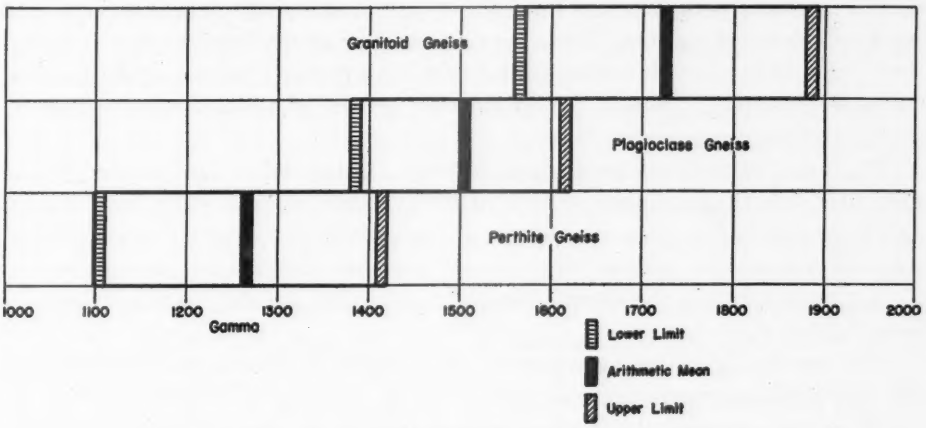


FIG. 2. Statistical analysis of magnetic values observed over gneisses.

Limestone

The limestone present in the area is also distributed in two well defined zones. The first and larger of the two may be designated as the Harlem Valley limestone belt. It consists of a highly crystalline and dolomitized variety, varying in color from white to buff, and may be considered also in part to be a dolomitized marble. It occupies an area of about thirty square miles in this survey, with its major axis extending for about ten miles in a north-south direction.

The smaller or Northwestern Limestone zone is located in the northwest corner of the area. It is triangular in shape and has an area of approximately eight square miles. It varies in color from gray to blue. This limestone does not exhibit the same high degree of metamorphism as that of the Harlem Valley belt and is not coarsely crystalline in character. These two limestones are believed by some, including Barth and Balk (1936), to be of the same age, and marked differences in their physical characteristics are attributed primarily to the degree of metamorphism to which they were subjected.

The values of the vertical component of the earth's magnetic field over these two limestone areas reflect primarily either changes in the magnetic sus-

ceptibility of the underlying basement complex and/or variations in the thickness of the overlying limestones; which is another way of describing variations in the distance from the magnetometer to the basement complex. The local mean value for the Harlem Valley limestone is 1,360 gammas, whereas that for the Northwestern Limestone zone is 1,650. This situation is discussed subsequently in more detail.

GEOMAGNETIC SURVEY

Introduction

An Askania magnetometer is used to measure the vertical component of the earth's magnetic field, ΔZ, at a total of four hundred and fifty-three regional and eighty-six detailed stations. These figures represent an average of about four stations per square mile. However, stations are spaced much closer in critical areas, whenever possible, to obtain a more detailed picture of the magnetic field in its relation to the geology of the area.

The usual corrections for temperature and diurnal effects are applied to the data field. The diurnal correction is made by establishing a daily base station and returning at intervals of about every two hours to repeat the observations. Any differences occurring in this manner are then distributed among the stations occupied during the interim. In addition, tie-ins are also made between the base stations.

The sensitivity of the magnetometer determined by means of a Helmholz coil was thirty-two gammas per scale division. This scale value is well suited for retional surveys because it usually does not require frequent adjustments in the field, and auxiliary magnets are only needed occasionally.

The exact location of all station sites are chosen carefully to avoid extraneous magnetic effects which might be introduced by making observations near communication and power lines, road culverts, pipe lines, wire fences, etc. The safe distance criteria for observations made near these objects are taken for the most part from Heiland (1941, p. 373).

Discussion of ΔZ Map and Cross Sections

The observed values for ΔZ are plotted on Figure 3 and contoured using a hundred gamma interval. Contours for every multiple of 500 gammas are represented by heavier lines in an effort to accentuate the presence of any existing trends. In order to compare the magnetic and geologic characteristics of the region, readers of this paper are referred to the geologic map of the area made by Balk (1936).

The comparative geologic and magnetic east-west cross sections of Figure 4 show the major changes in ΔZ in relation to the geologic characteristics of the area. Although the location of the major anomaly zones and their displacement in an east-west plane going from south to north is well defined in this figure, changes in magnetic values associated with lateral variations in lithology are not

too well defined because of the vertical scale factor. However, this relationship is shown adequately in Figure 5 where a vertical scale for ΔZ is chosen which demonstrates the changes in ΔZ caused primarily by differences in the magnetic susceptibility values associated with the gneisses, schists and limestones.

Four of the eight cross sections shown in Figure 4 are reproduced using this enlarged ΔZ scale of Figure 5. It becomes evident from this figure that as the lithology changes, for example from a gneiss to a schist or a schist to a limestone, a sharp break occurs in the magnetic profiles at or very near these lithologic boundaries. This situation is well defined especially at the contact between the Harlem Valley limestone and the Eastern Schist zone. The sharp break affords a valuable criterion in determining inter- and intra-formational contacts in regions where they are obscured by glacial overburden. Schwartz (1944) uses this method successfully in tracing the Duluth gabbro contact.

The average change in ΔZ, caused by polarization variations reflecting primarily pronounced changes in lithologic characteristics, varies between 200–300 gammas in this area. The absence of such breaks at a few interformational contacts in this figure may be explained by the fact that the magnetic observations are not made at or near these particular locations because swamps and lake areas make it inexpedient to establish stations at these points. However, a curve could be drawn connecting the observed points in these areas in such a manner that the curve is continuous but yet exhibits the break observed in the other cross sections.

The anomalies present near the western boundary of cross sections 3 and 4 in Figure 5 are not caused by polarization effects at interformational contacts in the strict stratigraphic sense of the word. They may be attributed to the presence of either more basic intrusions or segregations, together with their associated polarization contrasts, in the gneiss. They can be designated as "intraformational" contacts.

Some of the more significant characteristics of the vertical component of the earth's field in this area appear in Figure 3. For purposes of discussion and identification the area surveyed will be sub-divided into several rather well defined zones in the following manner:

Southern Gneiss Zone

Gneiss occurs in the southernmost part of the area. The magnetic values range in general between 1,400–1,600 gammas. They are typical of the "plagioclase" gneiss type of Barth's classification as discussed on page 231 and Table 1, and the magnetic gradient is very low. Several small areas in which slightly higher values, namely, about 1,800 gammas, occur are also found here. They may be interpreted as zones of more basic segregations present in the gneiss, or ones in which the disseminated magnetite content is slightly higher than the average for the region as a whole.

It should be noted in this connection that the altered ultrabasic dike discussed

PAWLING
41°35'
N

FIG. 3. ΔZ magnetic map of Carmel-Pawling Area (contour interval 100 gammas; — — — — county and state lines).

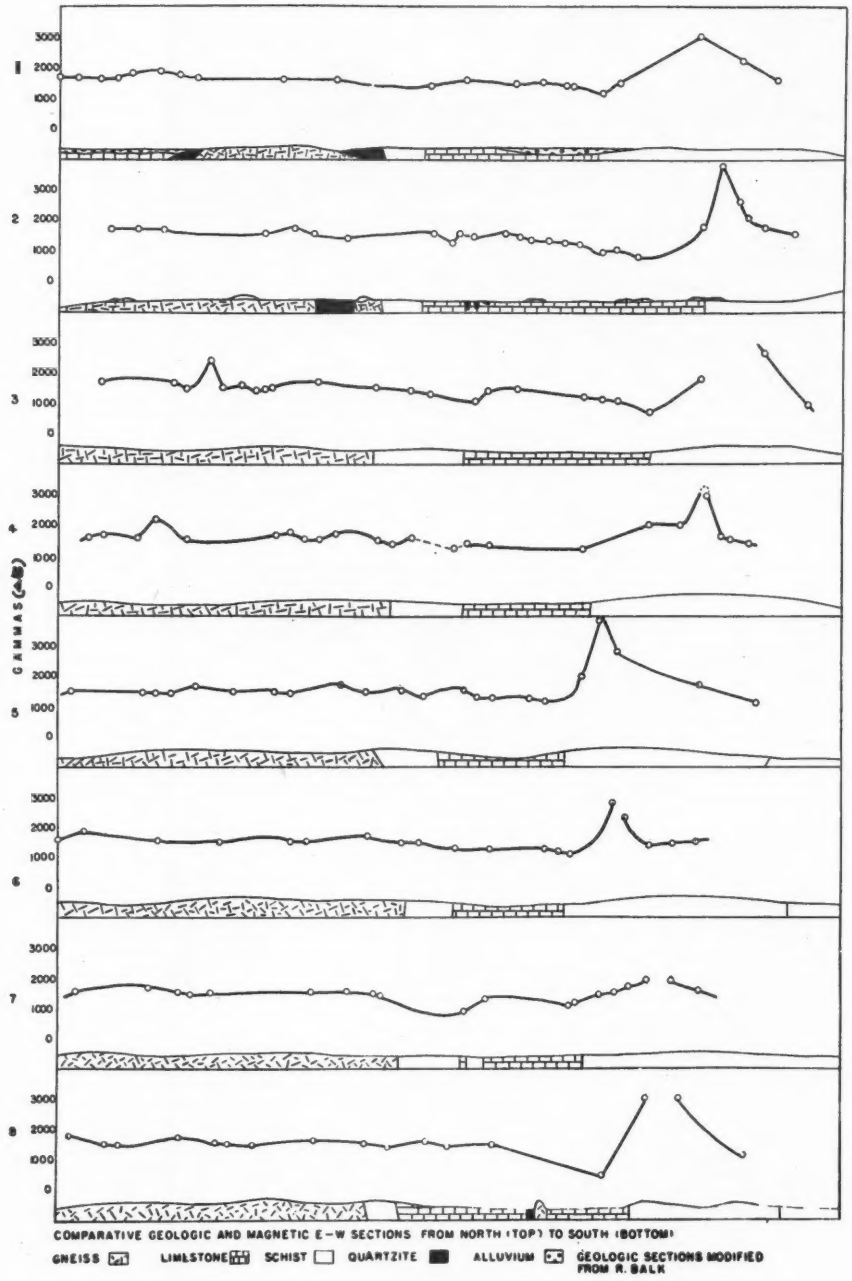


FIG. 4. Comparative geologic and magnetic east-west sections from north to south. (Horizontal scale, 1:187,500.)

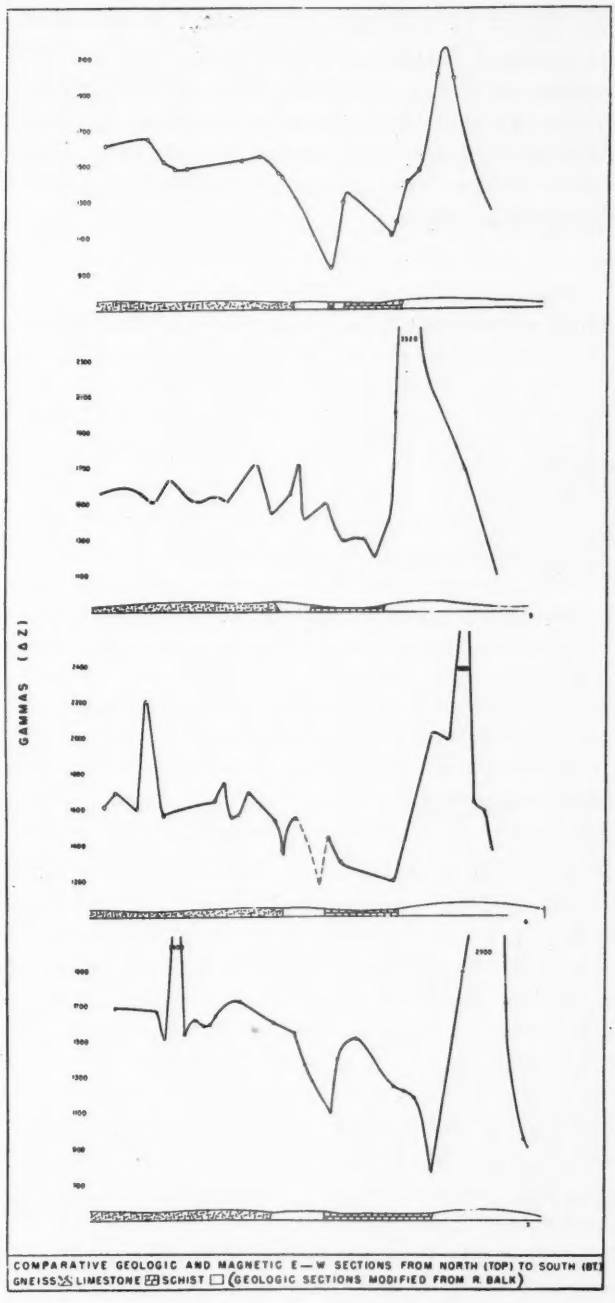

GAMMAS (ΔZ)
COMPARATIVE GEOLOGIC AND MAGNETIC E—W SECTIONS FROM NORTH (TOP) TO SOUTH (BE
GNEISS LIMESTONE SCHIST (GEOLOGIC SECTIONS MODIFIED FROM R. BALK)

FIG. 5. Comparative geologic and magnetic east-west sections from north to south. (Horizontal scale, 1:318,750.)

on page 230 and illustrated in Figure 1 is present in this area. The magnetic values exhibit a maximum increase of about 600 gammas more than the regional. They do not appear on Figure 3 because they are confined to a very narrow zone, about 300 feet wide, in the immediate vicinity of the dike itself.

Several minor positive magnetic anomalies also occur in the central part of the "plagioclase" gneiss zone. Their characteristics may best be summarized by means of the following table:

TABLE 2

CHARACTERISTICS OF MINOR MAGNETIC ANOMALIES OF THE "PLAGIOCLASE" GNEISS ZONE

Location	Maximum Value in Gammas	Local Regional Value in Gammas	Difference	Area in Square Miles
1. 4 miles northeast of Carmel	1,786	1,500	286	1
2. 3 miles northeast of Carmel	1,876	1,500	376	3.5
3. 3.5 miles west of Pawling	1,728	1,500	228	1
4. 5 miles southwest of Pawling	1,726	1,500	226	ca 1
5. 2 miles northwest of Carmel	2,140	1,500	640	—*

* Confined to immediate vicinity of ultrabasic dike.

The magnetic values as well as areal distribution show that the cause of these anomalies must be attributed to appreciable variations in the magnetic susceptibility of the formations outcropping or present at very shallow depths in this region. These differences in susceptibility are caused primarily by changes in the magnetite and/or ferromagnesian mineral content in the gneiss existing either in the form of igneous intrusives or more basic segregations. For example, the positive anomaly situated three miles to the northeast of Carmel is associated with an outcrop which may be classified as a diorite. A moderate amount of magnetite is found in most of the thin sections made from this outcrop. In addition, in those sections in which magnetite is absent relatively large amounts of ferromagnesian minerals such as hornblende are present. Thus the magnetic anomaly in this region may be attributed in part at least to the presence in greater concentration of these minerals as well as the magnetite. An intrusion of a syenite type is responsible for the anomaly found five miles southwest of Pawling. A small amount of magnetite occurs in the three thin sections made from this outcrop, and is chiefly responsible for this anomaly.

The presence of more basic segregations may be postulated to explain the origin of the remaining anomalies with the exception of No. 5 which correlates with the ultrabasic dike. However, the presence of glacial deposits in these regions makes it difficult to obtain sufficient additional geologic evidence to establish this point definitely.

Granitoid Gneiss

The northwestern part of the area may be sub-divided into two parts on both geologic and geomagnetic criteria, namely, (1) a northeast-southwest striking prong of pre-Cambrian granitoid gneiss approximately two and one-half miles wide by five miles long, (2) a dolomitic limestone buried for the most part under varying thickness of glacial and alluvial deposits.

The configuration of the isogams conforms rather closely to the general topographic outlines of the granitoid gneiss prong. In addition, the magnetic values over this prong average about 200–300 gammas more than those of the adjacent limestone areas and the magnetic gradient is approximately five times as steep. For example, it is necessary to go a distance of about three miles in the limestone region to observe a difference of 100 gammas, whereas a change of approximately 300 gammas in approximately one and one-half miles occurs over the granitoid gneiss prong. In the extreme northwest corner of the area the magnetic values again rise about 100 gammas above the regional value for the limestone area reflecting the change in lithology from a limestone to a schist.

The magnetic values in the granitoid gneiss prong may be sub-divided into two portions, namely, a southern and northern. The southern zone averages about one and one-half miles in width and the magnetic values vary between 1,600–1,700 gammas except for a series of four, more or less isolated but rather pronounced, magnetic highs. These highs are less than one-half mile in width and align themselves approximately parallel to the prevailing strike. Starting with the westernmost one the maximum values are 1,872, 2,206, 2,376 and 2,340 gammas respectively.

These anomalies may be caused by basic segregations in the gneiss, or lenses of gneiss having a higher magnetite content than that prevailing for the most part in the granitoid gneiss zone. Because of the presence of glacial deposits, the exact cause cannot be determined without resorting to some direct method such as drilling. However the probable causes may be limited to several possibilities on the basis of the geologic characteristics of the adjoining areas.

The northern zone averages about one mile in width. Its boundaries are defined by the 1,700-gamma isogam. The maximum magnetic value observed is 1,896 gammas, making a total range of almost 200 gammas more than the regional. The southern zone of the granitoid gneiss prong, on the basis of its magnetic and mineralogic characteristics, may be considered as a transition zone between the "plagioclase" gneiss area adjoining it to the south and the well defined granitoid gneiss zone comprising the northern portion of the prong.

Northwest Limestone Region

The magnetic values for the major portion of the limestone area situated immediately to the north of the granitoid gneiss prong vary approximately

between 1,600–1,700 gammas. In the extreme northwestern corner values up to 1,794 gammas occur. The isogams in both the gneissoid granite prong and the limestone region have a well defined northeast-southwest trend. Thus an average difference of about 100 gammas exists between the granitoid gneiss prong and the limestone area to the north. A similar situation exists elsewhere in the area surveyed. For example, the Harlem Valley consists primarily of limestone that is overlain for the most part by glacial deposits, swamps and thick alluvium. Here again the magnetic values average about 100–150 gammas less with respect to the adjoining Eastern and Central Schist zones and the "plagioclase" gneiss zone bordering to the east, west and south respectively.

The magnetic values, therefore, over most of the area surveyed are determined primarily by the susceptibility of the underlying gneiss and granitoid gneiss. Therefore, in regions where the limestone outcrops at the surface, decreases in observed magnetic values encountered there as compared to adjacent areas may be considered primarily as a measure of the thickness of the limestones overlying the gneiss or granitoid gneiss, provided the magnetic susceptibility of the underlying basement complex rocks remains essentially constant.

Harlem Valley Limestone Zone

The isogams in the Harlem Valley region have a predominating north-south trend and a rather steep gradient which is most pronounced on the eastern side. The valley also extends in a north-south direction and is located slightly to the east of the geographic center of the area. This north-south trend of the isogams represents a marked contrast to that existing in the western part of the area, where they trend northeast-southwest paralleling the trend of the granitoid gneiss. This indicates that the trend of the isogams over the exposed limestone areas is controlled primarily by the magnetic characteristics of the underlying pre-Cambrian metamorphics.

Northern Schist Zone

The isogams in this area also exhibit a fairly well defined north-south trend. The magnetic values range between 1,200–1,600 gammas with values in the vicinity of 1,500 gammas predominating. The magnetic gradient in this region is very small, with changes of only 100 gammas frequently occurring over distances of as much as two and one-half to three miles. The magnetic values for this region are in striking contrast to those found in the eastern portion of the area surveyed. The greatest range in observed values for the entire survey occurs in the latter region. Here the values vary from about 523 to more than 4,200 gammas. These extreme values occur in a series of three major anomaly zones exhibiting a pronounced north-south trend and extending for a distance of seven miles. They will be described in detail in the section dealing specifically with a discussion of the major magnetic anomaly zones in the Eastern Schist area.

QUANTITATIVE METHODS FOR DISTINGUISHING REGIONAL AND LOCAL ANOMALIES

Introduction

Several methods other than the second derivative and allied methods used frequently in connection with airborne magnetic surveys are available to determine "regional" values for magnetic surveys in order to have a datum plane from which to analyze quantitatively any anomalous zones that may have been surveyed. If well defined anomalies covering a comparatively small area appear in a survey, a base station may be selected at a point considered to be geologically "undisturbed" and observations having values greater or less than the value at this selected station may be classified as anomalous. The choice of a regional value for surveys covering appreciable areas can be made by using the values found in magnetic tables and charts, as for example, those published by the United States Coast and Geodetic Survey in Howe and Knapp (1935).

Another common method is based on cross sections made from the data. In this method the regional value is determined generally more or less by "inspection," i.e. a line is drawn by eye through the approximate midpoints of the irregularities appearing in the section and deviations above and below this line are considered to be anomalous.

A regional correction for the area surveyed was computed from data given by Howe and Knapp (1935) because a large area, approximately 130 square miles was involved. However, the correction was so small, about 7.5 gammas per mile, compared to the magnitude of the values observed, that it is not applied in the actual computations involving each station observation. However, it is felt that as an aid in evaluating the major anomalies of the Eastern Schist zone an accurate knowledge of the regional values especially in this particular zone would be highly desirable. Therefore the use of statistical methods for the determination of the regional value is used. A statistical analysis of the data should show also whether they are sufficiently well distributed throughout the area as a whole. Thus a check on the validity of the station spacing as well as the over-all significance of the magnetic data can be determined.

A check on the station distribution shows that the observations are well distributed over the region as a whole. For example, if Figure 6 is divided into four equal parts and these parts designated as I, II, III, and IV for the northwest, northeast, southwest and southeast quadrants respectively, the percentage distribution of the 453 magnetic observations among these quadrants is 23, 27, 21 and 29 per cent respectively. If the station distribution were perfect each quadrant would contain 25 per cent of the observations. The fact that the deviations from this figure for the actual cases only vary from a minimum of two per cent and a maximum of four per cent indicates that the over-all station distribution in this survey is such that a statistical analysis of the data is justified as a means of determining the regional value. In addition, another check on the significance and validity of the data may be made by computing the standard deviation. However,

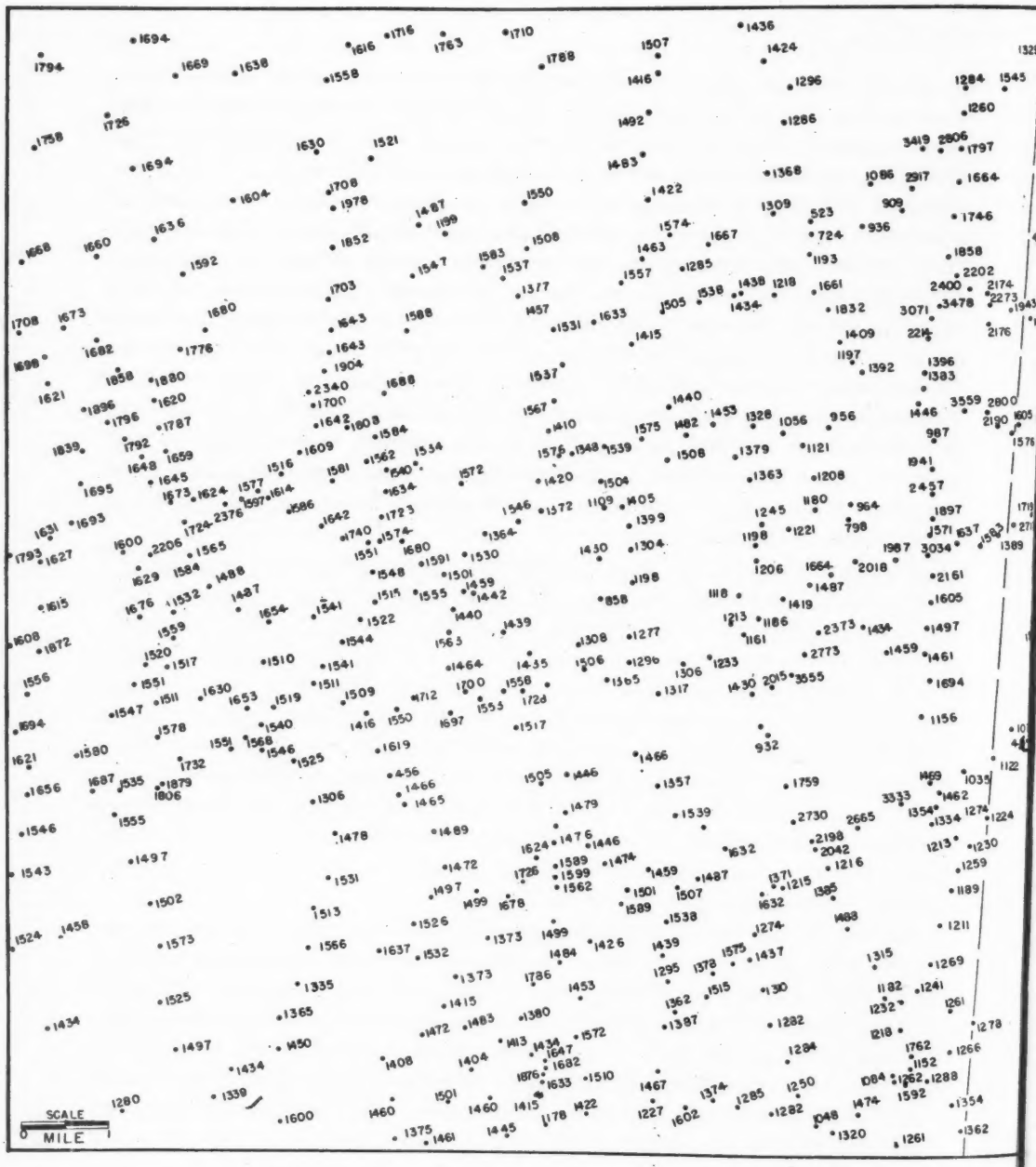


FIG. 6. ΔZ values used in preparing contours for Figure 3.

before using this method, a short discussion of the application of the arithmetic mean method may be helpful.

Arithmetic Mean Method

In treating these data statistically the arithmetic mean and the standard deviation are computed. The arithmetic mean is the most commonly used average because it is relatively simple to compute and understand. However, one major disadvantage is the fact that it may be distorted by extreme values and therefore be atypical. The arithmetic mean for the entire area based on the 453 magnetic observations is 1,555 gammas. However, if this value is calculated individually for each of the four previously designated quadrants, the resulting values are more significant. These latter values are summarized in the following table:

TABLE 3

REGIONAL VALUES FOR THE FOUR QUADRANTS USING THE ARITHMETIC MEAN AS A CRITERION

Quadrant	Regional Magnetic Value (Gammas)	Per Cent of Total Observation
NW	1,637	23
NE	1,600	27
SW	1,540	21
SE	1,450	29
Section		
North	1,618	50
South	1,495	50
West	1,588	44
East	1,525	46

The change in the regional value obtained by calculating the arithmetic mean between the northwestern and southeastern quadrants is in the same direction with respect to sign and about the same order of magnitude as that obtained when the regional is calculated from Howe and Knapp's (1935) tables. For example, the regional obtained by the former method is 187 gammas, whereas the latter is 123 gammas. However, if the difference in mean values between the northern and southern sections is used instead of the northwest and southeast quadrants the difference in regional values is the same as that obtained using the tables and charts of Howe and Knapp.

Since the isogonic lines in this area for the 1935 epoch have a rather well defined northeast-southwest trend it is more valid from a physical standpoint to use the difference between the northwest and southeast quadrants as the regional variation to serve as the basis of comparison between the results obtained from the tables even though the agreement is not quite as close.

The northeast-southwest trend of the isogonic lines is also evident even when the regional is computed on the basis of the arithmetic mean for each quadrant because the regional value for the southeast quadrant is the lowest, 1,450 gammas, and the highest, 1,637 gammas, is in the northwest quadrant. Thus the arithmetic mean method is valid for determining the regional values because it indicates almost the same magnitude as that shown on the U. S. Coast and Geodetic Survey chart, and it also indicates properly the direction with respect to sign of the regional changes. A similar method is successfully used by Van der Straeten (1945, p. 69) in constructing an isogonic map of Katanga for Epoch January 1, 1941.

Standard Deviation Method

Primarily because of certain limitations inherent in the arithmetic mean method and also in an attempt to evaluate the significance of the observations as a whole the standard deviation of these data is computed as well. If the arithmetic mean, 1,555 gammas, is used as the regional value then the upper and lower limits as determined by the standard deviation are 1,150 and 1,950 gammas respectively.

The standard deviation value is used primarily as a means of measuring the degree of reliability of a set of observations (Gavett, 1935, p. 180), as well as measuring the consistency of a set of observations (Gavett, 1935, p. 139). It might also be applied in a special manner, as a first approximation, as a means of determining the significance of magnetic data in terms of major and minor anomalies. In other words deviations from the regional, arithmetic mean, 1,555 gammas, using the standard deviation as a criterion for setting the upper and lower limits, may be attributed to disturbing effects such as:

(1) Major polarization effects existing at the surface or near interformational contacts (see Figure 5).
(2) Major variations in the thickness of the formations characterized by comparatively low susceptibilities overlying the pre-Cambrian formations which exhibit a much higher susceptibility.
(3) Major variations in the susceptibility characteristics of the pre-Cambrian formations underlying a series of formations having constant but lower susceptibility values, as well as constant thickness.
(4) Major variations in susceptibility in igneous intrusions and/or more basic "streaks" and segregations in the pre-Cambrian, where they are present at or very close to the surface.

Observations whose values exceed either the upper or lower limits of the standard deviation must be attributed to pronounced differences in magnetic susceptibility. Thus magnetic values observed in this survey, with only a few exceptions, which are less than 1150 gammas and more than 1950 gammas are attributable to one of the four causes listed above. These limits check well with the values observed in the field as demonstrated in Figure 3, because all

the observations associated with the major positive and negative anomaly zones of the Eastern Schist zone fall outside of these prescribed upper and lower limits as determined by the standard deviation value obtained for the data as a whole.

Another check can be made involving an empirical method, on the validity of the data obtained with the station spacing used. It consists of asking a person to contour the values shown in Figure 6 without being told anything of the geologic characteristics of the area itself. The agreement between the trends of the contours drawn under these conditions and those shown in Figure 3 is striking. In only one instance did any appreciable difference appear. It is confined to a rather localized region in the southeastern portion of the area where a sufficient number of observations can not be obtained readily because of the presence of swamps.

METHOD OF CORRELATING MAJOR GEOLOGIC FEATURES WITH REGIONAL MAGNETIC TRENDS

The methods in the preceding sections are quite suitable for determining regional values for use as a basis for correcting observed ΔZ values in the computation of magnetic anomalies. In addition, information pertaining to the correlation of regional magnetic trends with the major geologic features of the area can also be obtained by using a modification of one of these methods. For example, if instead of dividing the area into four quadrants, as described on page 243, the number were to be increased to 156, i.e., one square for approximately every three-quarters of a mile, and the average values contoured as suggested in Van der Straeten's method, then the over-all regional magnetic picture should be rather well defined. The results of this method are shown in Figure 7.

The chief difference between the contours shown in Figure 7 and those in Figure 3 lies in the fact that the former are controlled primarily by the dominating magnetic characteristics of the major "basement complex" geologic features of the area, whereas the influence of magnetic characteristics reflecting more localized geologic features, some of which may be in the "basement complex" as "intrabasement features," are accentuated in the latter. The latter variations tend frequently to mask or substantially modify the major trends. This necessitates the construction of an isogam map similar to that of Figure 7 in order to be able to differentiate among them.

Therefore it is not surprising to find that a more marked relationship is seen to exist in Figure 7 than in Figure 3 between the isogam trends and the areal distribution of the major geologic features found in this area as mapped by Balk (1936). In addition, if the adjusted magnetic values, derived from the standard deviation method, are used as criteria in delimiting the boundaries between the major geologic features, the agreement is quite pronounced in almost all the cases.

The details of this method, whose application is illustrated in Figure 8, may be summarized as follows: compute the arithmetic mean, standard deviation, and upper and lower limits for each of the seven major geologic subdivisions in this area from the magnetic values observed in each. These factors are sum-

marized in Table 4. This table from the standpoint of delimiting interformational boundaries also demonstrates that nothing significant can be obtained by merely averaging magnetic values over different types of geologic formations because the average ΔZ value over each of the different major rock types such as gneiss, schist and limestone taken as units only differ by a maximum of 12 gammas. However, the average sigma values for these same types differ appreciably as well as consistently. For example, the average sigma values for the gneiss, schist and limestone areas as units are 143, 116 and 85 respectively. Thus the greatest variation in magnetic values is found over the rock type in which the most pronounced susceptibility contrasts occur. This situation is to be expected

TABLE 4

SUMMARY OF LOCAL SIGMAS AND MEANS FOR THE SEVEN GEOLOGIC ZONES

Zone	Sigma	Mean (In Gammas)	Upper Limit (In Gammas)	Lower Limit (In Gammas)
Granitoid Gneiss	158	1,720	1,880	1,560
Plagioclase Gneiss	116	1,500	1,610	1,390
Perthite Gneiss	158	1,260	1,420	1,100
Average for Gneiss Types	(143)	(1,493)	(1,637)	(1,350)
Central Schist	98	1,530	1,628	1,432
Eastern Schist*	125	1,480	1,605	1,355
Average for Schist Zones	(116)	(1,505)	(1,616)	(1,393)
Harlem River Limestone	115	1,360	1,475	1,245
Northwestern Limestone	55	1,650	1,705	1,595
Average for Limestone Types	(85)	(1,505)	(1,595)	(1,420)
Regional Values*	395	1,550	1,945	1,155

* Exclusive of major anomaly zones suspected of containing amphibolite lenses.

because of a maximum variation in magnetite and ferromagnesia mineral content in this rock type as compared to the others.

MAJOR MAGNETIC ANOMALY ZONES IN THE EASTERN SCHIST AREA

Description

Three major anomalous zones become evident from a survey of the region described as the "Eastern Schist Area." The greatest variations in ΔZ of the entire magnetic survey occur, namely, a minimum value of 523 and a maximum of 4,200 gammas, with values greater than 2,500 gammas occurring frequently.

The anomalous areas occur in a north-south trending zone having a length of about seven miles and a width varying from a maximum of about two miles in the southern portion to about one and one-half in the north. Their areal distri-

bution as well as relationship to one another may be seen in Figure 3 and Figure 9. In addition, in Figure 9 the outline of the boundaries of the schist zone as well as the outline of the thousand-foot topographic contour are also included to demon-

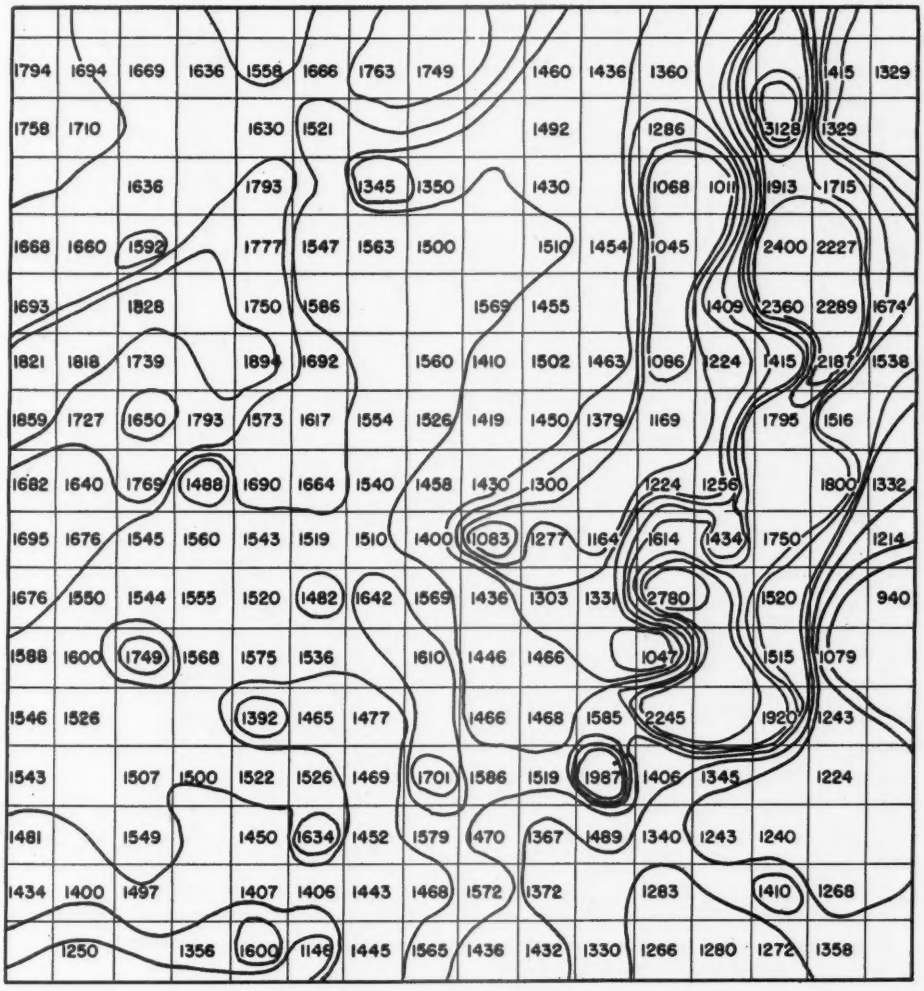
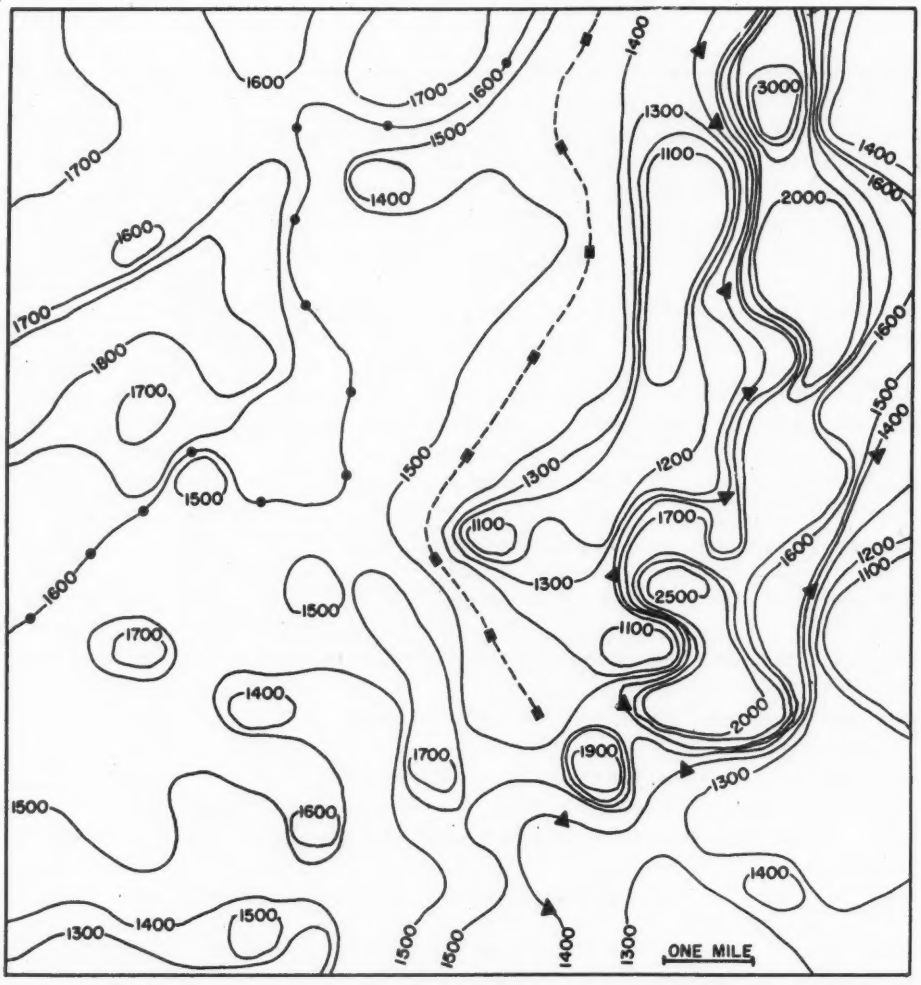


FIG. 7. Average ΔZ values for observations obtained within three-quarter mile squares.

strate the fact that although there is no significant relationship between these anomaly zones and topography, they are all confined to the schist zone.

The ΔZ values observed with the regional station spacing may be contoured as shown in Figure 3 and Figure 9. Four more or less well defined zones appear and they may be described as the southern, central, northern and transition



Boundary between granite gneiss and plagioclase gneiss; also between granite gneiss and Central Schist Zone.

Boundary between Central Schist Zone and Harlem River Limestone.

Boundary between plagioclase and perthite gneiss; also perthite gneiss and Eastern Schist Zone, and Harlem River Limestone and Eastern Schist Zone.

FIG. 8. Interformational boundaries drawn on the basis of statistical evidence.

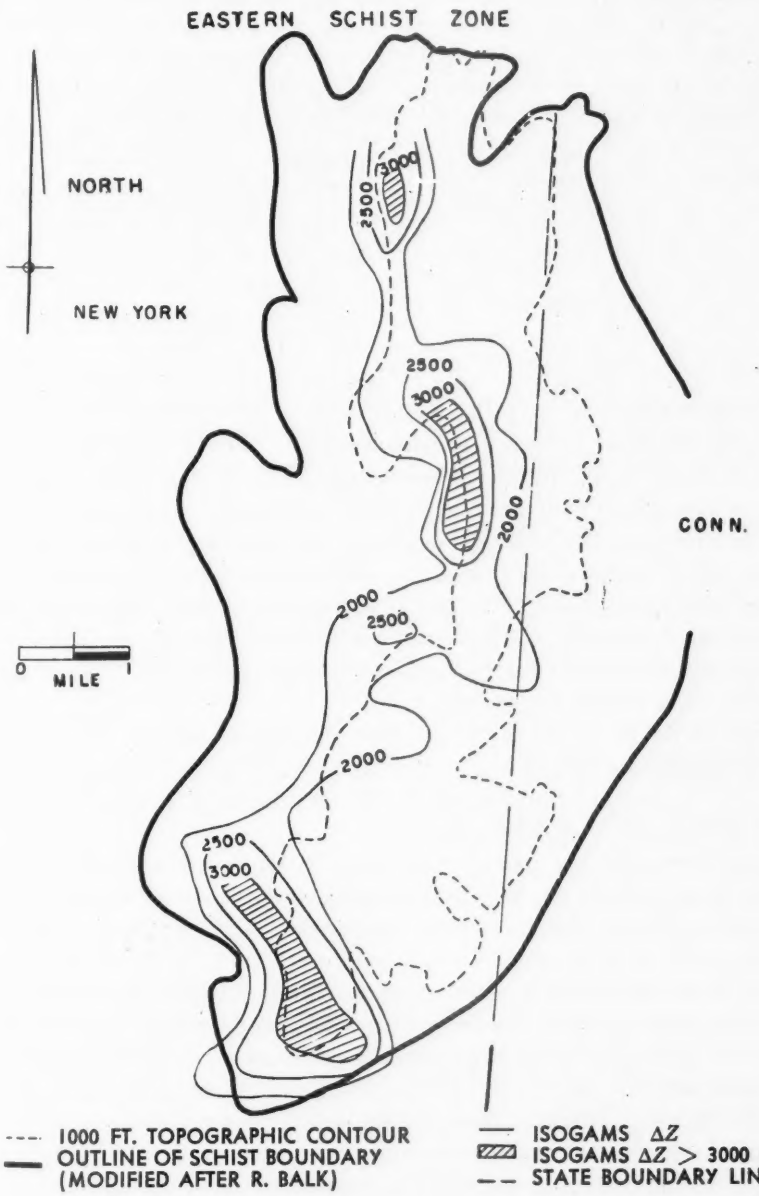


FIG. 9. Generalized sketch showing absence of any significant relationship between topography and schist boundaries with the major anomalies.

anomalous zones. Their physical characteristics may be summarized in the following table:

TABLE 5

GEOGRAPHIC CHARACTERISTICS OF THE EASTERN SCHIST AREA ANOMALIES

Anomaly	Area (miles)	Length (miles)	Width (miles)
Southern	2.00	2.5	0.75
Central	3.00	3.0	1.00
Northern	0.75	1.5	0.50
Transition	0.50	1.0	0.50

Probable Origin

The origin of the anomalies in the Eastern Schist Area presents one of the most interesting problems arising from this magnetic survey. Several theories may be proposed to account for this phenomenon. The direct evidence at this time consists of the actual values of the vertical component of the earth's magnetic field observed, together with geologic and geochemical evidence obtained from outcrops in and near the margins of this area. Thin sections were made from some of these outcrops in order to be better able to determine mineralogic and petrographic characteristics of the rocks. In addition, several chemical analyses are available in the literature (Barth, 1936) from schist specimens obtained only a short distance from the area surveyed.

One interpretation as to the origin of these anomalies based on the contour method used in Figure 3 might be that some large inclined dike-like mass or more basic segregation situated at considerable depth was responsible. This statement is predicated on the following reasoning:

(1) Each positive anomaly area appears to be accompanied to the west by an associated low area indicative of the presence of the north pole of the anomalous mass sufficiently close to the surface to appreciably modify the surrounding magnetic field.

(2) From the apparent width of the anomaly areas as shown in Figure 3, it would appear on the basis of the commonly used half-width depth criterion that the depth to the geologic feature responsible for the anomaly could be at least several thousand feet.

However, if the facts available from the geologic evidence are also taken into consideration, an entirely different interpretation as to the cause of the anomalies must be made. For example, the presence of numerous lenses of amphibolites in the schist near the Connecticut state border of the Eastern Schist Area has been noted on Balk's geologic map. The areal distribution and size of these lenses are such that with the regional station spacing used in this magnetic survey numerous stations could have been occupied over them, assuming that they are

present beneath the glacial deposits and soil which obscure the bedrock over a very high percentage of the region in which the anomalies occur.

To test this hypothesis the commonly accepted method is applied of working from the known to the unknown, used successfully for example by Krahmann (1936) in locating by magnetic methods the extension of the Witwatersrand shales beneath the Ventersdorp limestone. A magnetic profile using a station spacing of fifty feet is made across some known outcrops of amphibolite as shown on Balk's map. The longest profile is over a series of three such lenses located just east of the Connecticut-New York state line adjacent to the Dutchess and Putnam

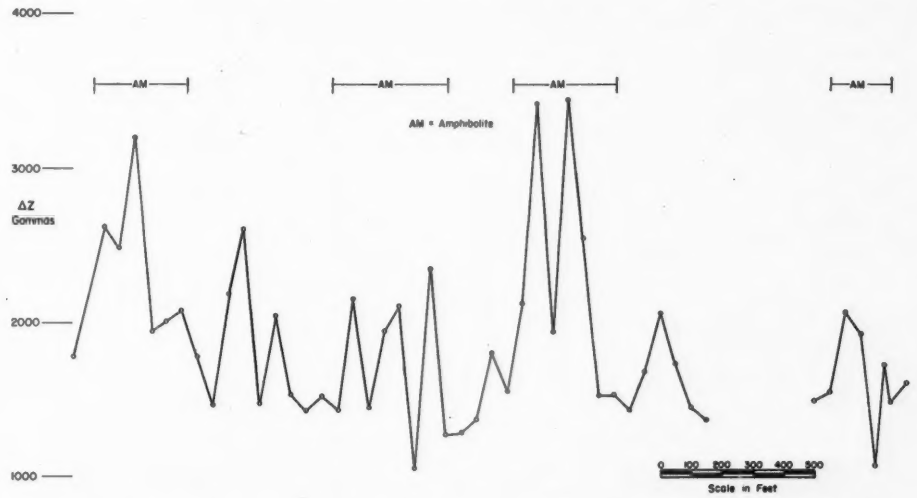


FIG. 10. Detailed magnetic profile No. 1 across known amphibolite lenses (station spacing 50 feet).

County lines. The results are shown in Figure 10. This figure shows that the changes in ΔZ are quite pronounced over a short horizontal distance. For example, values ranging between 1,000 and 3,600 gammas occur within a distance of 400 feet. The width of the positive anomalies is very small and generally does not exceed 100 feet. This latter fact indicates that the cause of the anomalies must be sought for at extremely shallow depths.

Similar conditions were also observed over a much shorter section, namely 300 feet, across a known amphibolite lens situated about one-half a mile to the west on the Dutchess-Putnam County borderline, and also shown in Figure 10. A combination of very low as well as very high magnetic values, with the latter predominating, appears to be characteristic over the amphibolite lenses which were surveyed in detail. In addition to the cases described above, very low values near amphibolite lenses were also observed even with the regional station spacing. For example, a value of 1,156 gammas occurs at a point on Figure 3,

whereas the stations on either side are about 500 gammas higher. This value also appears in a north-south profile shown in Figure 11. Balk (1936, p. 757) describes the occurrence and origin of the amphibolite as follows:

"In the schist belt north of the Eastern gneiss spur, there is a great 'swarm' of amphibolite lenses. These are regarded as of igneous origin, because at two points (hill 1,260, half a mile west of the north-south road, and 2.5 miles east-northeast of Patterson; hill, 1,180 three-quarters of a mile northeast of hill 1,260) the rock grades into coarse equigranular diorite. The amphibolite forms a multitude of concordant lenses and sills in the schist, and has been folded isoclinally with it (Fig. 37). . . . The amphibolite lenses are crossed by scores of straight and massive pegmatite dikes, their association presumably due to the fracturing of the rocks

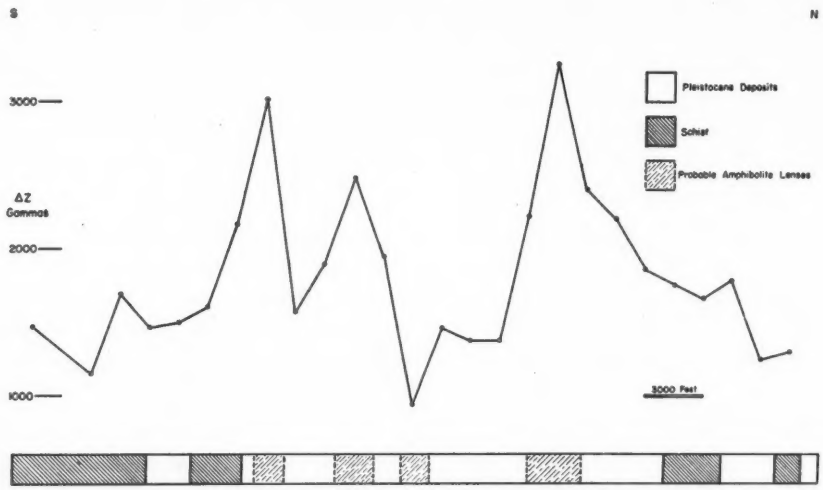


FIG. 11. North-south section using regional station spacing to show probable location of additional amphibolite lenses.

during a late stage, rather than to genetic relations between amphibolite and pegmatite."

This isoclinal folding of the amphibolite with the schist can be used to account for the presence of the rather narrow zone of very high magnetic values together with an accompanying broader zone of slightly lower but still appreciably greater than regional values seen several times in Figure 10. The geologic counterpart of this explanation is apparent in Figure 37 of Balk's (1936, p. 768) paper. Although the width of the specific example illustrated in this figure is only 60 feet the same principles would apply in cases where the width was greater, or a repetition of this situation occurred.

The fact that these amphibolite lenses are crossed by broad pegmatite dikes might account occasionally for the presence of the very low magnetic values generally accompanying the positive anomalies found in these areas. The magnetic susceptibility of pegmatite dikes is generally very low because of the low

magnetite and ferromagnesian content. Thus the magnetic values appearing over them would be much less than the regional magnetic value expected for an area characterized primarily by the presence of schist. Having determined the major magnetic characteristics to be expected over the amphibolite lenses in this area by means of a closely spaced (50-foot intervals) magnetic survey over actual outcrops, a series of magnetic traverses is then made in those areas suspected of containing amphibolite lenses on the basis of information gained during the original regional survey as contoured in Figure 3.

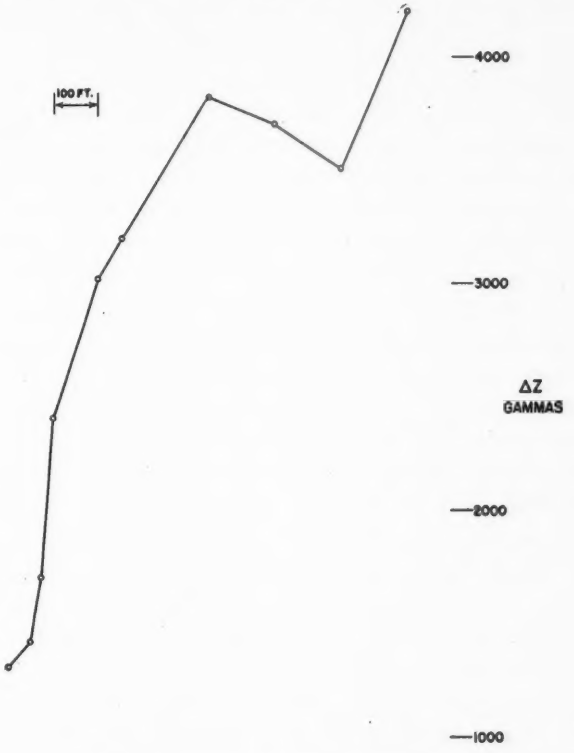


FIG. 12. Detailed magnetic profile No. 2.

Before discussing some of these examples in detail it is in order to discuss the similarity in major characteristics between Figures 10 and 11. It would appear at first glance that the two profiles are almost the same in many of these respects, i.e., each contains several sharp magnetic highs and lows, together with appreciable areas in which regional or near regional values predominate. However, the horizontal scale of Figures 10 and 11 differ by a factor of 15, although the vertical scales are the same. In Figure 10 one inch = 100 feet and a station spacing of 50 feet is used, whereas in Figure 11 one inch = 1,500 feet and a regional station spacing of approximately every 1,500 feet is used. The values

shown in this figure are taken directly from Figure 3 of the original regional survey without introducing any additional observations. Since three very high, one very low and several moderately high magnetic values were observed over the known amphibolite lenses within a distance of approximately 2,000 feet, it is highly probable that in areas characterized by similar geologic features, but where the bedrock is obscured, a regional station spacing of about 1,500 feet

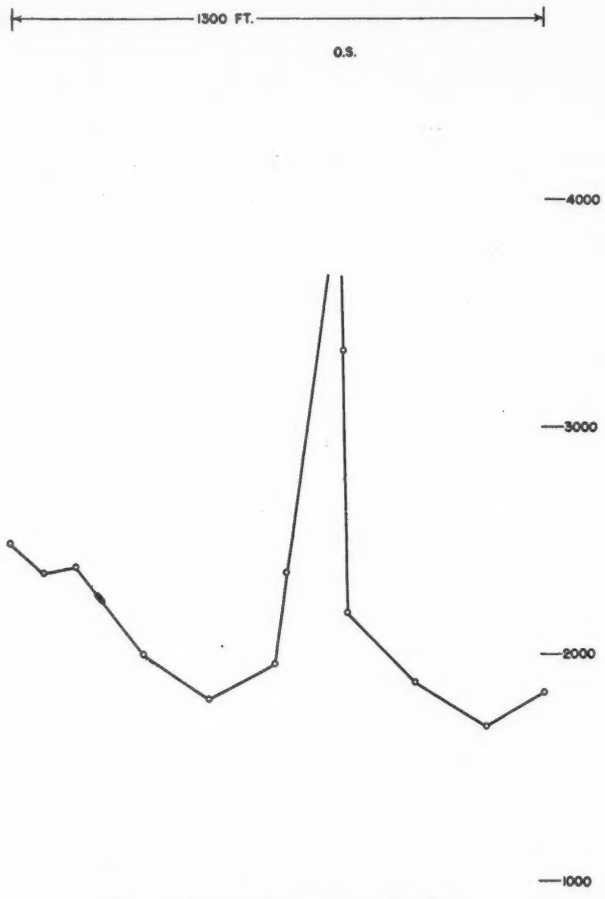


FIG. 13. Detailed magnetic profile No. 3.

would be quite apt to intercept some very high as well as low magnetic values. This appears to be the case, for example, in Figure 11. Therefore the assumption may be made that additional lenses of amphibolite are also present in the anomalous areas of the Eastern Schist Area although they are obscured by glacial overburden.

Data from additional stations are available for a distance of almost a mile along another detailed traverse across the southern portion of the central anomaly

zone and are shown in Figure 12. It is apparent from the profile in this figure that the western boundary is well defined on the basis of four stations situated in the first 100 feet. The magnetic values start at 1,320 gammas and increase steadily to 2,400 gammas within this distance. In addition, within the next 250 feet the values continue to increase to 3,820 gammas. The following 300 feet are characterized by a decrease in value to 3,500 gammas followed by a rise to a maximum value of 4,200 gammas in the next 150 feet.

Data from another detailed magnetic profile located about one-half mile to the east of the one shown in Figure 12 are shown in Figure 13. The observations along this profile occurring at distances of from 25–150 feet are all greater than the regional value in this vicinity. The magnetic values starting at the eastern boundary tend in general to rise gradually from 1,800 to about 2,600 gammas. If the slope of this gradual rise were to be extrapolated toward the profile shown in Figure 12, it would intersect approximately at the maximum value of 4,200 gammas recorded for this profile. In addition to this gradual rise a narrow but very large positive anomaly occurs near the eastern boundary. It is only 100 feet wide but has a maximum amplitude of more than 4,400 gammas because the magnetometer went off scale even with the addition of an auxiliary magnet.

Therefore, in order to define accurately the boundaries of the amphibolite lenses and/or the associated intrusions, which together undoubtedly constitute the cause of the unusually high values observed in the anomalous zones of the Eastern Schist Area, this entire area would have to be covered with a network of stations in which a 50-foot interval would be a maximum. This is outside the scope of the original regional geomagnetic survey for this area and would entail the establishing of literally thousands of additional stations. Hence it is not in keeping with one of the major purposes of this survey, namely to demonstrate that the *major* regional magnetic and geologic characteristics of an area may be defined with reasonable accuracy using a minimum of stations. It should therefore be kept in mind when studying Figure 3 that the contour lines over the Eastern Schist Area serve merely to indicate in broad outline the major anomalous zones of this area. Their principal function is to indicate places in which to conduct very detailed magnetic surveys if the precise outline and number of amphibolite lenses and/or dioritic intrusions should be needed as a part of any subsequent geologic studies in this area.

CONCLUSIONS

The major conclusions which may be drawn from the results of this geomagnetic survey are as follows:

(A) A well defined correlation exists for the most part between changes in the vertical component of the earth's magnetic field, ΔZ, and the distribution of major lithologic units of this area. For example, the tripartite classification of the gneiss into granitoid, plagioclase and perthite types is in agreement with a

division made on the basis of variations in ΔZ magnetic values measured over them. This relationship is summarized in Table 6.

TABLE 6

STATISTICAL ANALYSIS OF MAGNETIC VALUES OBSERVED OVER GNEISS

Type of Gneiss*	Number of Cases	Standard Deviation	Average Value	Upper Limit (Values in Gammas)	Lower Limit
Granitoid	52	158	1,720	1,880	1,500
Plagioclase	133	116	1,500	1,610	1,390
Perthite	49	158	1,260	1,420	1,100

* Arranged in order of decreasing magnetite and ferromagnesian mineral content on the basis of Barth's (1936) chemical analysis and the author's thin section studies.

This table demonstrates that the three principal types of gneiss occurring in this area all exhibit well defined magnetic characteristics. Not only is there a pronounced difference between the average values for each of the three types, but more significantly, there is little overlap of the magnetic values between the upper limit of one type and the lower limit of another. Thus the three major gneiss types can be differentiated on their magnetic characteristics, which are primarily a reflection of their respective magnetic susceptibilities.

(B) The use of average magnetic values by themselves for differentiating geologic zones may be meaningless. However, if the standard deviation is also computed, in order to determine upper and lower limits, a significant correlation can be made between variations in magnetic values and geologic characteristics for a given area.

(C) A broad correlation between magnetic and geologic characteristics on a regional scale can be shown to exist in this area with the station spacing used when the data are analyzed statistically.

(D) ΔZ measurements with a regional spacing, such as used in this survey, are sufficient to indicate the probable presence of local lithologic subunits such as the amphibolite lenses and associated igneous intrusives in those portions of the Eastern Schist Area overlain by widespread glacial deposits. Similar lenses of amphibolite seem to be absent in the Northern Schist Area on the basis of magnetic values observed there.

BIBLIOGRAPHY

Bahnemann, F., "Discussion on R. Krahmann's Paper," *Proc. Geol. Soc. S. Africa* (1936), p. lxxii.

Balk, R., "Structural and Petrologic Studies in Dutchess Co., New York, Part I: Geologic Structure of Sedimentary Rocks," *Bull. Geol. Soc. Amer.*, 47 (1936).

Barth, T., "Structural and Petrologic Studies in Dutchess Co., New York, Part II: Petrology and Metamorphism of the Paleozoic Rocks," *Bull. Geol. Soc. Amer.*, 47 (1936).

Brandl, W., "Erdmagnetische Untersuchungen im Brockenmassif," *Abh. der Preuss. Geol. Landes., N. F.*, 188 (1939) 82 pp.

Dana, J. D., "Geological Relations of the Limestone Belts of Westchester Co., New York, *AJS* 3rd Ser., Vol. XX (1880).

———, "Geological Relations of the Limestone Belts of Westchester Co., New York, *AJS* 3rd Ser. (1881).

———, "Geological Relations of the Limestone Belts of Westchester Co., New York," *AJS* 3rd Ser. (Appendix, 1881).

Fettke, C. R., "The Manhattan Schist of Southeastern New York and Its Associated Igneous Rocks," *N. Y. Acad. Sci. Ann.*, Vol. 23 (1914).

Gavett, G. I., *First Course in Statistical Methods* ((McGraw-Hall Co., 1925).

Heiland, C., *Geophysical Exploration* (Prentice-Hall, Inc., 1940), 1033 pp.

Howe, H. H., and Knapp, D. H., "United States Magnetic Tables and Magnetic Charts for 1935," *U. S. Coast and Geodetic Survey* (1938), 161 pp.

Krahmann, R., "The Geophysical Magnetometric Investigations on Westwitwatersrand Areas Between Randfortein and Potchefstroom, Transvaal," *Trans. Geol. Soc. of S. Africa* (1936).

Koeberlin, F. R., "The Brewster Iron-Bearing District of New York," *Econ. Geol.*, vol. 4 (1907).

Mather, W. W., "Geology of the first Geological District," *Natural History of New York* (1843).

Newland, D. H., "The Mineral Resources of the State of New York," *N. Y. St. Mus. Bull.* (1919), 112 pp.

Schwartz, G. M., "Tracing the Duluth Gabbro Contact with a Magnetometer," *Econ. Geol.*, 39 (1944).

Van der Straeten, H., "Isogonic Map of Katanga for Epoch Jan. 1, 1941," *Terr. Mag. and Atmos. Elect.*, 50 (1945).

LOGGING OF DRILL HOLES BY THE NEUTRON, GAMMA METHOD, AND GAMMA RAY SCATTERING*

HENRY FAUL† AND C. W. TITTLE‡

ABSTRACT

The intensity distribution of secondary gamma radiation resulting from neutron capture has been measured in simulated drill holes, of various types such as cased and uncased, empty and water-filled. The intensity of neutron-capture gamma rays depends on the hydrogen content of the rock. In a six-inch well, it increases with hydrogen content at points within about 16 inches of the neutron source and decreases at more distant points. The absolute gamma intensity is greatly reduced when non-hydrogenous gamma-ray or neutron absorbers, e.g., lead or boron are introduced between logging probe and formation. The slope of logarithmic gamma ray intensity *vs.* distance remains virtually constant. It changes with the hydrogen content of the formation and offers a means of quantitatively estimating porosity behind casing despite extraneous absorption. The slope can be measured automatically in the well by two gamma detectors placed in a probe at fixed distances from a neutron source. Hydrogenous material between probe and rock increases the slope. Two or three inches of drilling mud seriously impair the sensitivity.

Gamma radiation scattered by the walls of drill holes necessitates proper shielding for detectors used in (n, γ) logging with a radium-beryllium source. A shielded detector is predominantly sensitive to the hard neutron-capture gamma rays and tends to discriminate against the softer scattered radiation. The scattered intensity decreases with increasing bulk density of the formation. Under favorable conditions, continuous logs of formation density as a function of depth can be obtained.

INTRODUCTION

The commercially practiced art of neutron logging is based on the detection of the gamma rays that result from the capture of slow neutrons by nuclei in the rock. The process was introduced as a logging method by Pontecorvo (1941) and has been practiced largely in conjunction with a gamma ray logging service for oil-field drill holes. The method yields qualitative information that is of practical value in many instances. Casing and well fluid are purported to have little effect on the results, but few definite claims have been made outside the commercial and patent literature. The authors have made some experiments to study the basic physical phenomena inherent in the technique and their results are summarized in this paper.

The exact nature of the rock surrounding a drill hole is seldom known and cannot be adapted to experimental study. Therefore, a simulated drill hole was used surrounded by various "formations" whose compositions were accurately known. We then investigated the conditions that would be encountered by a neutron logging instrument in this "well." A small, cylindrical, Geiger counter, free to move vertically through the hole, detected the gamma intensity point-by-point at various distances from the fixed source of primary radiation (neu-

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tron and/or gamma) located on the axis of the experimental hole. By interposing gamma ray and neutron absorbers between the "logging instrument" and the "formation" we have attempted to locate the origin of the gamma rays detected.

The gamma rays measured by the neutron probe detector consist largely of: 1) gamma rays resulting from Compton scattering of the primary gamma rays associated with the neutron source, 2) gamma rays emitted upon the capture of neutrons, mainly slow neutrons, and 3) radiation from surrounding formations. Absorbers and several intense sources of neutrons and gamma rays were used in an effort to distinguish between the first two sources of gamma radiation.

This study confirms the generally accepted opinion that neutron logs can be very useful under favorable conditions. However, even though only a limited number of measurements were made it appears that the present commercial methods could be improved. On the other hand, several inherent limitations of the technique are outlined. Well fluid between the probe and the formation is the most serious factor.

ACKNOWLEDGMENTS

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We are indebted to Messrs. T. R. Madden and E. T. Miller, who set up the equipment used in these experiments, and carried out preliminary tests. The assistance of Mr. A. Y. Sakakura and Mr. Frank Johnson is also acknowledged.

GENERAL CONSIDERATIONS

Consider first the processes that occur when a rock is bombarded by fast neutrons from a point source placed in a long, empty borehole. The neutrons from such a source have a broad range of energies (Anderson, 1948). Most of the neutrons penetrate into the rock, collide with numerous nuclei, and rapidly lose their energy in the process. Most of the neutrons reach thermal energies of less than about 0.1 ev before being absorbed. For the present, it will suffice to describe the resulting thermal neutron intensity as decreasing approximately in an exponential manner in all directions from the source. In a homogeneous medium, the distribution will be radially symmetrical about the center of the source. When a cylindrical opening, such as an empty borehole or the essentially "empty" logging instrument is introduced, the low energy neutrons diffuse up and down the hole. Thus, the thermal neutron distribution is distended axially. The degree of distension depends among other factors on the albedo, i.e., "reflec-

tion" coefficient of the interface, which is largely a function of the hydrogen content of the medium. A four-inch hole in water will cause about a three-fold axial extension of the distribution.

In a hydrogenous medium the thermal neutrons do not diffuse very far from the point where they attain thermal energy. They have a short mean-free-path and are captured in the immediate vicinity giving rise to one or more capture gamma rays. Hydrogen is the predominant capturing nucleus in most sedimentary rocks. It emits a 2.23 Mev gamma ray and forms an atom of deuterium (heavy hydrogen). The next nucleus, in order of importance as a thermal neutron absorber, is chlorine. It emits a spectrum of gammas with peaks between four and seven Mev (Wilson, 1950). The slow neutron capture by other nuclei in sedimentary rocks is small when hydrogen or chlorine are present in appreciable concentrations as shown in Table 1.

TABLE 1

MASCROSCOPIC THERMAL CAPTURE CROSS SECTIONS OF SUBSTANCES FOUND IN COMMON SEDIMENTARY ROCKS. N = NUCLEI PER CM^3, σ_a = NUCLEAR ABSORPTION CROSS SECTION

Substance	$N\sigma_a$ (cm^{-1})
Water	0.0207
Salt (halite)	0.7350
Saturated brine	0.1230
Quartz	0.0039
Alumina (density 2.0)	0.0054
Calcite	0.0070
Dolomite	0.0087

The capture gamma rays penetrate the rock, suffering Compton collisions and photoelectric absorption. The logarithm of the over-all gamma absorption in the rock is very roughly proportional to the density of the material. Hence the gamma intensity measured in the well depends not only on the spatial distribution of the thermal neutrons but also upon the density of the rock. Furthermore, a fairly small thickness of a heavy element, for example iron in casing, results in a large photoelectric absorption, due to the dependence of the photoelectric effect on the fourth power of the atomic number, Z^4.

Thus far, another effect has been ignored that contributes to the gamma intensity in the well; namely, the heavy gamma background of the neutron source itself. A Ra-Be source, which is the type generally used commercially, emits about 10^4 times as many gammas as neutrons. Most of these gammas have energies less than 1 Mev, but some range as high as 2.2 Mev (Evans, 1948). The source is generally housed in the bottom of the logging probe and heavily shielded from the detector. However, the radial thickness of the shield, usually lead, is limited by the diameter of the instrument and the well. It is rarely possible to shield the source with more than two or three inches of lead in the radial direction. Consequently, a sizable fraction of the more energetic gammas penetrates into

the rock, is scattered back into the detector and contributes to the measured gamma intensity.

There is yet a third source of gamma rays, the natural radioactivity of the rock. In sandstones and limestones it is generally safe to neglect this activity, but shales and mudstones are sufficiently active to make a significant contribution to the total gamma intensity, even if a very intense source of neutrons is used. From the standpoints of economics and personnel safety, it is impractical to use Ra-Be sources greater than about two curies. If the radioactivity of the rock is known from a separate gamma ray log, it is a simple matter to correct the neutron curve for the natural gamma intensity.

APPARATUS

The simulated drill hole was built up inside a common 36-inch corrugated-steel highway culvert, with a plate welded across one end. A 6-inch (I.P.S.)

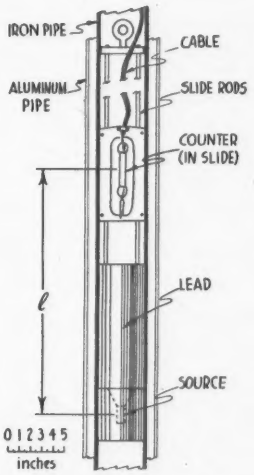

FIG. 1. Schema of source and detector arrangement.

aluminum pipe, closed at one end, was placed coaxially in the up-ended culvert, extending through its full length of 8 feet and forming the walls of our hole. The space between the pipe and the culvert was filled by the various media simulating the formation. The following substances were used: water, dry sand, water-saturated sand, drained sand containing water, brine-saturated sand, drained sand containing brine. The brine contained 17 per cent NaCl by weight, and the sand was pure screened 30–40 mesh "Flint Shot" with a porosity of 39 per cent and a yield factor of 0.75. The water content of the drained sand thus was 9.6 per cent by volume. Excepting the dry sand, all the media were effectively infinite, i.e. the loss of neutrons across the boundary of the tank was negligible. All the media were infinite as far as the scattered gamma rays are concerned.

The "logging instrument" was constructed in a 4-inch (I.P.S.) steel pipe, extending the full height of the tank and placed coaxially in the 6-inch aluminum pipe. It is shown in Figure 1. The radiation source was in the center of a lead cup, 3.8 inches in diameter and 4.6 inches high. The bore of the cup was $\frac{3}{4}$ inch in diameter and 1.5 inches deep. The cup was fitted to a lead plug, 12.1 inches long and 3.8 inches in diameter. The depth of the cup was adjusted with a lead shim, so that the sources always rested against the bottom of the plug. The detector slide moved on two steel rods and held a Geiger-Muller tube, three-quarters of an inch in diameter, with one thirty-second inch brass walls and about one and one-half inches of effective length. The detector could slide up and down through a distance of about two feet. At the point of its closest approach, the center of the tube is about 17 inches above the source and four and one-half inches above the top of the lead plug. The GM tube was connected to a scale-of-64. The performance of the counter was frequently checked by calibrating with a small radium source in air.

The following radiation sources were used in these experiments:

Ra-Be contains 1.03 g of radium intimately mixed with 4.37 g of beryllium, compressed and sealed in a cylindrical stainless steel container, 0.730 inch in diameter, one inch high, and 0.05 inch thick. The source had been calibrated against the ORNL neutron (Ra-Be) source and found to emit about 11.6×10^6 neutrons/second.

Po-Be (polonium-beryllium) contained about 0.420 curie of polonium, intimately mixed with 6.9 g of beryllium, compressed and sealed in a stainless steel container, 0.730 inch in diameter, one and one-half inches high and 0.050 inch thick. The calculated emission of the Po-Be source was about 9.5×10^5 neutrons/second on May 12, 1949.

The strengths of the two neutron sources were compared by measuring the thermal neutron distribution in four-inch aluminum and iron pipes in water. The resulting neutron emission intensity ratios, Ra-Be/Po-Be were 12.7 and 12.2 respectively. All measurements made with the Po-Be source are normalized to the strength of the Ra-Be source and corrected for the polonium decay (half-life, 138 days).

Large Po-Be sources emit a complex gamma-ray spectrum (Bell and Jordan, 1950) of very low intensity. They are ideal for (n, γ) logging, but they are seldom used in the field because of the high operating cost resulting from the short lifetime of polonium. Production of artificial polonium in nuclear reactors is possible and might materially reduce the future cost of these sources.

Ra Source contains 1.0 g. of radium, sealed in a platinum capsule inside a stainless-steel case, 0.72 inch in diameter, one inch high, and about one-sixteenth inch thick.

Co Source contained about 2.5 curies of cobalt^{60} (July, 1949) as a metallic pellet, one cm in diameter and one cm high. The pellet was housed in a steel-topped aluminum case, measuring 0.730 inch in diameter and one inch high. The half-life of cobalt^{60} is 5.3 years.

PROCEDURE

With the proper formation in the barrel, a source was placed in the lead cup and the assembly lowered into the well. The counter was warmed up, slid to the bottom position on its rails. and the activity counted for a few minutes. The counter was then raised a few inches and the activity measured again. The process was repeated until the counter had moved the full length of its rails. The counting period was progressively increased to keep the statistical uncertainty negligible wherever possible.

The iron pipe (probe) always contained only the source in its shield, the detector, etc. The space between the probe and the aluminum well wall was either empty or filled with water or other substances mentioned below.

THE DISTRIBUTION

Our experiments show that the shapes of most of the secondary gamma ray distributions can be approximated by the expression $I=Ce^{-\alpha l}$ where I is the intensity at a point along the axis of the pipe, C is a constant of the experiment (the ordinate intercept), α is the slope factor, and l is the axial distance from the source to the point at which I is considered.

The integral of the intensity between two points, L_1 and L_2, along the pipe axis is simply

$$I_i = (I_1 - I_2)/\alpha$$

where I_1 and I_2 are the intensities at L_1 and L_2. The integral value I_i, will be proportional to the reading of a detector of length $L=(L_2-L_1)$ placed between the two points. If the detector is very long I_2 becomes negligible, and the expression for I_i is further simplified. We have found that a 24-inch detector can be considered very long for most practical purposes. In subsequent sections of this paper, the *integrated distribution* will be discussed. I_i will be referred to as evaluated from the top of the lead plug ($L_1=13$ inches) to $L_2=\infty$ and the distribution assumed to be simple logarithmic.

DETECTION OF HYDROGEN

Using the Po-Be source, because its gamma background is negligible, the gamma intensity was measured in the well surrounded by moist sand and water-saturated sand. The results, plotted in Figure 2, show that the secondary gamma distribution caused by neutron capture is almost simple logarithmic. The slope of the distribution in sand increases with increasing hydrogen content. The curves intersect at a certain distance from the source, illustrating that the distance between neutron source and the effective center of the gamma-ray detector is a critical parameter in the design of a neutron-logging probe. If the detector were placed at the intersection of the curves, the instrument would fail to distinguish media of sharply different hydrogen content.

FAILURE TO DETECT BRINE

In another series of experiments, Tittle, *et al.* (1949) have shown the extent of thermal neutron capture by the chlorine nucleus in brine. The thermal capture cross section of chlorine is 31.5 barns, many times greater than the equivalent cross section of any other element commonly found in rocks. A series of tests was conducted in this investigation to determine what can be observed from the (n, γ) log of brine-bearing sediments.

Using the Ra-Be neutron source, the gamma intensity was measured in an empty 6-inch hole through mixtures of sand and brine. The first mixture con-

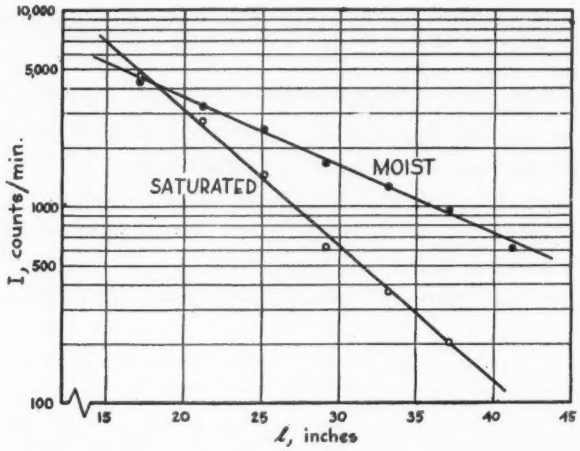

FIG. 2. Gamma intensity as a function of distance from the neutron source in holes through moist sand (9.6% H_2O) and saturated sand (39% H_2O). Po-Be source.

tained 39 per cent brine by volume and the second 9.5 per cent, or the amount retained by the sand after draining. The brine was about 65 per cent saturated, corresponding to an NaCl content of about 17 per cent by weight in the brine.

In spite of the high concentration of the brine, no significant difference was observed between the results with brine and the equivalent data for water. The results are shown in Table 2.

INTERFERING FACTORS IN (n, γ) LOGGING

Casing

From the viewpoint of logging, casing may be considered simply as an absorber interposed between the probe and the formation. It will strongly attenuate the flux of secondary gammas into the well and will absorb a considerable fraction of thermal neutrons in their travel in and out of the well. Inelastic neutron scattering does not appreciably affect the flux or spectral distribution of fast neutrons from the source into the formation. The ultimate (n, γ) log is

affected by the absorption of both neutrons and gammas, and it seemed desirable to examine the two effects separately. Investigating first the absorption of gamma rays, a layer of lead shot was poured into the space between the inner pipe (the probe) and the six-inch outer pipe. The layer had a bulk density of 6.8 g/cm^3 and a thickness of 2.0 cm. Lead shot was selected because the metal has a relatively low capture cross section for slow neutrons and a high gamma ray absorption coefficient. To absorb neutrons granulated boron carbide (B_4C) was used between the pipes. The layer was again two cm thick and had a density of 1.2 g/cm^3. The B_4C layer had a macroscopic thermal capture cross section of about

TABLE 2

FAILURE OF THE (n, γ) LOG TO DETECT THE DIFFERENCE BETWEEN BRINE AND WATER IN SAND. HOLE DIAMETER: SIX-INCH, NO WELL FLUID. INNER PIPE (LOGGING PROBE) DIAMETER: FOUR-INCH, ONE-QUARTER-INCH STEEL WALL, HOLE LINED WITH SIX-INCH ALUMINUM PIPE, ONE-QUARTER-INCH THICK. RA-BE NEUTRON SOURCE; BRINE CONCENTRATION 17 PER CENT NaCl BY WEIGHT.

Distance from Source (inches)	Gamma Ray Intensity			
	Moist Sand (9.5 per cent hydrogenous fluid)		Saturated Sand (39 per cent hydrogenous fluid)	
	Water	Brine	Water	Brine
17.2	10,600	10,800	9,340	9,300
23.2	5,080	4,900	3,620	3,530
29.2	2,380	2,200	1,290	1,250
35.2	1,120	1,100	514	450
41.2	570	520	220	180

36 cm^{-1} and thus was completely opaque to thermal neutrons. Boron was selected because its capture gamma ray energy is much less than that of any other neutron absorber. Thermal neutron capture by boron is an (n, α) process, but 93 per cent of the captures produce an excited state of Li^7 which decays with the emission of a gamma ray of 420 kev energy (Hornyak and Lauritsen, 1948). The iron wall of the logging probe absorbs most of the soft gamma rays, so that the gamma flux from the boron can be neglected.

The gamma ray absorption in the boron carbide was small, but not negligible, especially in the holes through saturated sand, where the neutron slowing-down distance is smaller, and most of the gamma rays traverse the layer at sharper angles than they would in holes through material of lesser hydrogen content. In order to separate the effect of neutron capture from the small gamma absorption, it was necessary to make another set of measurements with an absorber that is virtually transparent to neutrons but has the same density and a mean atomic number roughly similar to the boron carbide. A mixture of pure silica sand and coarse ground pumice was prepared for the purpose. Its gamma absorption was checked against the boron carbide with a strong, pure source of monochromatic gamma rays (cobalt^{60}) and found identical. The measurements made with the sand-pumice mixture were compared with data obtained with air between the

pipes, and the resulting factor was used to correct the B_4C data for gamma absorption.

The effect of the pure gamma absorption and pure neutron capture on the gamma intensity in holes through moist and water-saturated sand is shown in Figure 3. The most remarkable feature of these graphs is the parallelism of the curves. The slope of the curves changes very little when absorbers are introduced, in spite of the fact that the integrated gamma intensity is greatly affected by the absorbers. In saturated sand, the lead reduces the gamma intensity integral to about 67 per cent of the value for air, because most of the neutron capture gam-

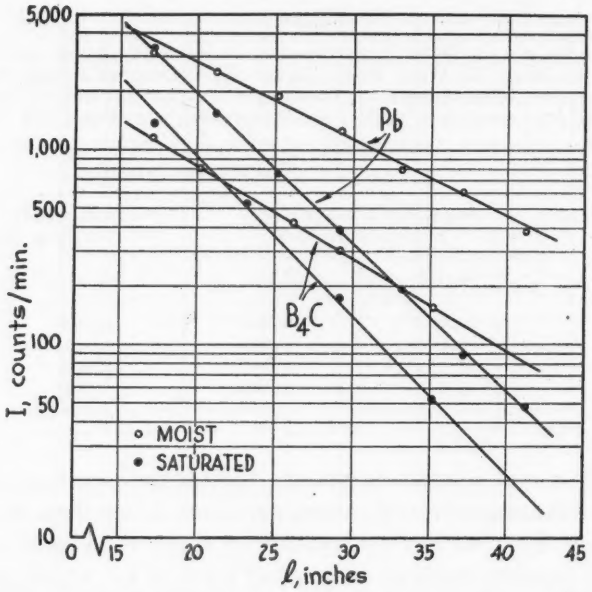

FIG. 3. Gamma intensity in holes through moist sand (open circles) and saturated sand (solid circles) with neutron absorber (B_4C) and gamma ray absorber (Pb) in the space between the probe and the formation. Po-Be source.

mas are very penetrating. The boron, on the other hand, reduces the ultimate secondary gamma intensity integral to about 31 per cent of the value for air between the pipes. The equivalent figures for moist sand are 69 per cent for lead and 21.2 per cent for boron. It may be concluded that about three quarters of the slowed neutrons that would later produce detectable capture gamma rays cross the borehole at least once.

Drilling Mud

It is usually impractical to pump the well dry before logging operations. All mud is strongly hydrogenous and disturbs the neutron distribution. An auxiliary experiment has shown that the neutron slowing down and absorption in ordinary

barite mud (density 1.4 g/cm³) is much the same as in water, and in this investigation it is fair to use water *in lieu* of mud in general.

Well fluid absorbs the gamma rays only slightly, much as other light materials discussed earlier, but greatly distorts the thermal neutron distribution. The resulting effect on the gamma intensity is shown by the data in Figure 4. When the space between probe and formation is filled with water, the gamma intensity decreases, and the slope steepens. The steepening is particularly pronounced in holes through material of low hydrogen content. The hydrogen sensitivity of the log is correspondingly reduced.

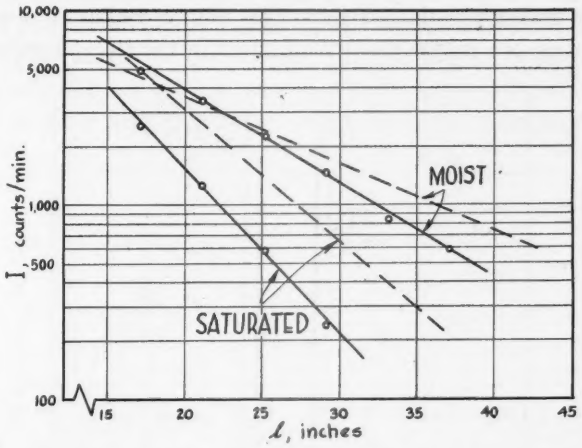

FIG. 4. Reduction of gamma intensity by well fluid (water). The solid lines show the intensity in holes through moist (9.6% H_2O) and saturated (39% H_2O) sand with two-cm layer of water between probe and formation. The dashed lines are the distributions in the same holes with the well fluid removed. Po-Be neutron source.

This situation may be remedied partially by selecting and adjusting the diameter of the probe so as to displace most of the fluid in the well. Such a procedure is suggested in the patent literature, but has obvious practical limitations. The radial fluid thickness in our experiments was kept constant, i.e., two cm.

On the other hand, if a good log of the hole diameter is obtained (caliper log) and approximate knowledge of the nature of the well fluid, the log may be corrected on the basis of empirical data obtained in a simulated well. No amount of correction, however, can make up for the loss of sensitivity caused by the fluid, and every correction involves additional error. A neutron log run in a mud-filled hole of unknown and irregular diameter has very little geological value.

GAMMA RAY SCATTERING

The Ra-Be neutron sources used in logging utilize the (α, n) reaction of beryllium for the production of neutrons. The cross section for the (α, n) reaction is very small, so that the resulting rate of neutron emission is much smaller than the

emission of gamma rays from the radium. The ratio is approximately 10,000 gammas for each neutron emitted.

The lead shield in the logging probe can be made sufficiently long to absorb all but a negligible fraction of the gammas passing from the source directly toward the detector. In a radial direction, however, the shielding is much less effective because of the obvious limitations on the probe diameter. Consequently, a large fraction of the more energetic gamma rays from radium is permitted to escape and interact with the surrounding formations. The probability that the gamma will be scattered into the detector is relatively small, but the great intensity of the gamma radiation from the source makes it necessary to consider the scattering as a major disturbing effect in the (n, γ) logging process.

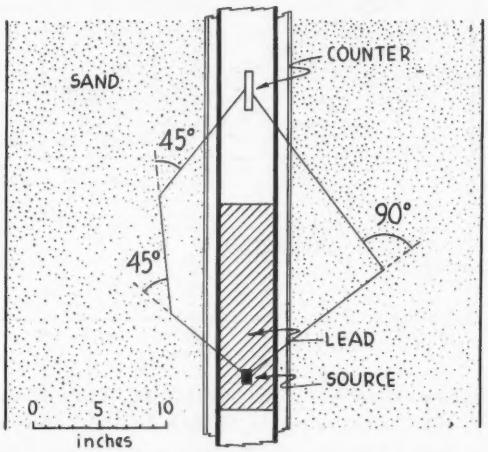

FIG. 5. Path of typical photons scattered into the detector. Assuming an original energy of 1 Mev, the twice scattered photon loses about half of its energy in the two Compton collisions. The same photon scattered through 90° loses two-thirds of its energy in a single collision.

The scattered radiation is much less energetic than the hard gamma rays resulting from neutron capture by the nuclei of hydrogen, chlorine, iron, and the other common capturing elements. In each Compton collision, the impinging gamma ray loses some of its energy, as described by the Compton equation

$$\Delta\lambda = \lambda_c(1 - \cos\theta)$$

where $\Delta\lambda$ is the increase in wavelength (the energy E of a gamma ray is given by $E = hc/\lambda$ where h is Planck's constant, c is velocity of light, and λ is the wavelength), λ_c is a constant (the Compton wavelength, $2.47 \cdot 10^{-10}$ cm), and θ is the angle between the incident and scattered gamma quanta.

The analytical computation of the total effect for several collisions is difficult (Hirschfelder, *et al.*, 1948) but we may consider two typical cases (Fig. 5). First, it may be assumed that a 1 Mev gamma is scattered into the detector after a single collision. Taking $\theta = 90°$, the following expression is obtained:

$$\Delta\lambda = \lambda_c = 2.47 \cdot 10^{-10} \text{ cm.}$$

The wavelength of the impinging 1 Mev photon is

$$\lambda = hc/E = 1.23.10^{-11} \text{ cm}$$

and, the scattered, degraded photon will have a wavelength

$$\lambda' = \lambda + \Delta\lambda = 3.7.10^{-10} \text{ cm}$$

corresponding to the energy of 0.33 Mev or a net loss of two-thirds of the energy of the incident photon.

As a second typical case, start with the same incident photon and consider two collisions at $\theta = 45°$. The $\Delta\lambda$ for such a collision is $0.723 .10^{-10}$ cm, and the twice degraded photon will have the energy $E' = 0.46$ Mev, or a net loss of more than one-half of the energy of the incident photon. Figure 6 shows the fractional energy loss per collision for various values of θ plotted as a function of the energy of the incident gamma ray. It follows that the Compton-scattered gamma rays

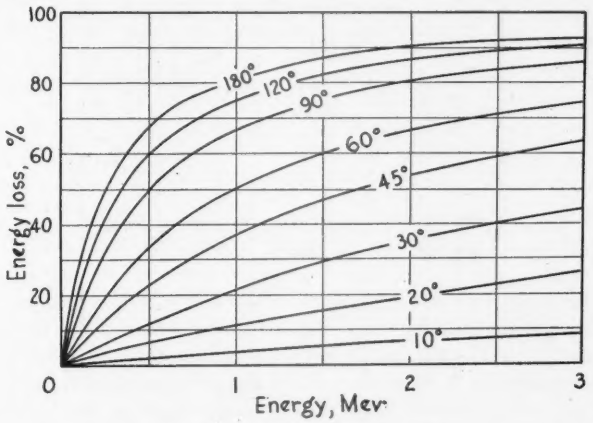

FIG. 6. Energy loss per Compton collision for various angles of scattering plotted as a function of the energy of the incident gamma.

from the Ra-Be source are generally much softer than the gammas from slow neutron capture. Speaking in orders of magnitude, the scattered radiation will have an energy of about 0.5 Mev, while the energies of the capture gammas will be several Mev. It should be noted that whereas the radium gamma spectrum is well known, the knowledge of the energies of the thermal neutron capture gammas is only fragmentary. The total energy acquired by the capturing nucleus can be computed accurately from the known mass differences, but the full energy may not be released in the form of a single quantum. The spectra have been measured for only a few elements, but generally speaking, the radiation is known to be hard. (Boron is an exception with a known 0.42 Mev gamma ray.)

By surrounding our detector with a shield made of an element with high atomic number ("thick-walled detector" (Fearon, 1949)) the scattered radiation can be markedly attenuated with respect to the capture gamma rays, thus largely

eliminating the contribution from scattering. The effect was examined experimentally by the same methods described in an earlier section. Two and one-half curies of cobalt^{60} were used as a source of pure gamma rays (Lind, *et al.*, 1949). The source was placed in the same lead shield previously used, with source, shield and detector all housed in the four-inch steel pipe. The six-inch aluminum pipe was surrounded alternately by moist sand and by water-saturated sand. The space between the pipes was alternately filled with B_4C ($\rho = 1.2$ g/cm^3) which has a small average atomic number, and with lead shot ($\rho = 6.8$ g/cm^3).

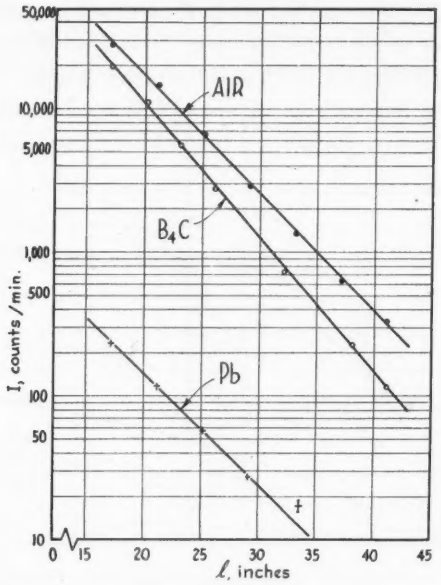

FIG. 7. Scattered gamma ray intensity in holes through moist sand with a two-cm layer of air (solid circles), B_4C (open circles) and lead (crosses) between instrument and formation. Co^{60} gamma ray source.

The results of the measurements in moist sand are shown in Figure 7, with the logarithm of scattered radiation intensity plotted as a function of distance from the source along the axis of the hole. The plots are again approximately simple logarithmic. The greatest intensity is observed when the detector hangs in an empty hole shielded only by the one-quarter inch of iron of the inner pipe. When the light absorber is placed between the inner and outer pipes, the integrated intensity drops to 64 per cent of its former value. The equivalent reduced value for saturated sand not plotted here, is 65 per cent. The slope changes slightly as a result of Compton scattering in the light absorber. When the lead shot is placed between the pipes, the integrated intensity for moist as well as saturated sand drops to 0.85 per cent of its former value, but the slope does not change appreciably. From a practical viewpoint, it can be said that the two-cm layer of lead shot absorbs all but a negligible fraction of the scattered gamma rays.

The data confirm that a properly shielded detector will be sensitive only to the hard capture radiation, making it possible to use Ra-Be neutron sources for (n, γ) logging, in spite of their high gamma emission. This point has also been verified experimentally by running logs with a Ra-Be source and the gamma ray-free Po-Be source using lead shot to shield the detector as before. The results are plotted in Figure 8 for moist and water-saturated sand. The data from the two sources check closely, and the two-cm layer of lead shot is clearly sufficient to shield out the scattered gamma radiation of the radium.

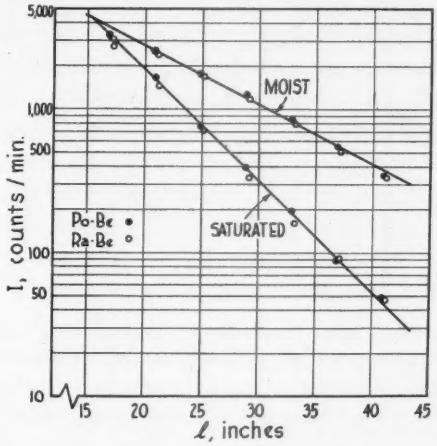

FIG. 8. Gamma ray intensity from two sources (Polonium-Beryllium: solid circles, and Radium-Beryllium: open circles) of equivalent neutron strength but widely different gamma emission in holes through moist (9.6% H_2O) and saturated (39% H_2O) sand with two cm of lead shot between the detector and the formation. The absorber (equivalent to a 1.2 cm layer of solid lead) is sufficient to reduce scattered radiation from the Ra-Be source to a negligible level.

To illustrate the comparative importance of scattered and neutron capture gamma rays, the gamma intensities were measured in the empty holes (unshielded detector), through moist and water-saturated sand, using the Ra-Be and Po-Be neutron sources and a pure Ra source. The resulting curves for moist sand are shown in Figure 9. The scattered gamma intensity is actually greater than the neutron effect at distances less than about 22 inches away from the source in our equipment, but falls off sharply and becomes negligible beyond 40 inches.

THE DENSITY LOG

The results of the gamma-ray scattering studies have another interesting aspect. The probability that a gamma will undergo a Compton collision is determined, among other things, by the electron concentration of the material upon which the radiation impinges. The electron concentration, in turn, is roughly proportional to the density of the material. Experiments were conducted using media of three distinct densities: water ($\rho = 1$), moist sand (ρ 1.65), and water-

saturated sand ($\rho = 1.95$). If the integral of the scattered gamma intensity is plotted as a function of density of the formation, the points fall on a straight line (Fig. 10).

Using a probe with a strong source of fairly hard monokinetic gamma rays shielded from a long, thin-walled detector, a log of scattered gamma intensity, plus natural radioactivity of the rock can be obtained. A second logging run,

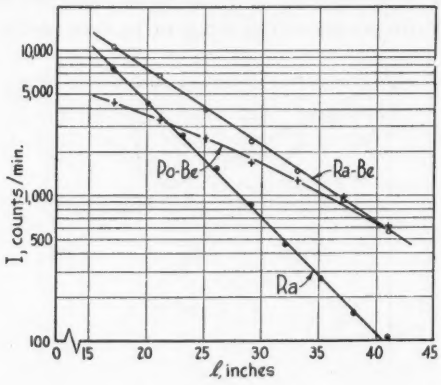

FIG. 9. Gamma ray intensity from three sources, normalized to roughly equivalent strength: Neutron plus gamma (Ra-Be), neutron only (Po-Be), and pure gamma (Ra). Empty hole through moist sand.

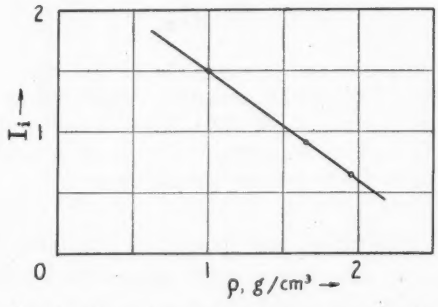

FIG. 10. Integrated scattered gamma intensity I_i plotted as a function of rock density ρ. The source is Cobalt^{60} and the hole diameter six inches, effectively uncased. The logging probe diameter is four and one-half inches with one-quarter inch steel wall.

made with the same instrument, but with the gamma ray source removed gives the natural radioactivity as a function of depth. Subtracting the results of the second run from the first curve, we obtain a log of rock density plotted as a function of depth. A similar technique is mentioned in the patent literature and should have considerable geological value.

SUMMARY AND CONCLUSIONS

The experiments with (n, γ) logging indicate that the method of simultaneous measurement of gamma ray intensity and rate of attenuation offers a means of

quantitatively estimating the hydrogen content of porous formations behind casing. Simultaneous measurement of the slope and intensity of secondary gamma radiation with two detectors placed at different distances from the neutron source eliminates a number of uncertainties and gives a log of considerably greater geological value than the method currently practiced in the field. Drilling mud and other strongly hydrogenous well fluids seriously impair the usefulness of a (n, γ) log, unless the liquid layer separating the probe from the formation is very thin and its thickness accurately known.

The chlorine content of a hydrogenous medium does not materially affect the slowing down of neutrons in the rock, but merely reduces the total number of thermal neutrons. The number of neutrons captured per unit time remains unchanged, no matter what the macroscopic capture cross section of the rock may be, and is equal to the number of neutrons emitted by the source. However, the chlorine changes the locus of capture by reducing the thermal diffusion length, i.e. the distance between the point where the neutron dropped to thermal energy and the point where it is captured. On the other hand, the capture gammas of chlorine have different energies from the gammas from hydrogen. The results show that in sand, as a porous medium, these differences are either negligible or they tend to compensate. The (n, γ) logging method cannot distinguish between water and brine as interstitial fluids in sand.

The mean diffusion length of thermal neutrons in hydrogenous media is only a few centimeters. Hence, it follows that the average effective neutron is captured within a few cm of the point where it became thermal. In the process of slowing down, however, the neutrons have made several dozen collisions with the nuclei of the rock and, on the average, have traveled more than a foot away from the source. The actual magnitude of this distance is an inverse function of the hydrogen content of the rock. Consequently, the neutron log indicates the slowing-down properties of an appreciable thickness of rock, in spite of the fact that the recorded hard capture gammas actually come from a fairly thin veneer of rock surrounding the bore hole. The mean thickness of this veneer is determined by the hardness of the capture radiation. The interference from the softer scattered radiation can be overcome by shielding the detector with a layer of lead, of the order of one-half inch thick.

Of the two common types of portable neutron sources, the Po-Be is better suited for (n, γ) logging because it has a negligible gamma background. At present, however, its use in the field is impractical because of prohibitive cost. Ra-Be sources are less expensive in operation, but should be used only with properly shielded (thick-wall) detectors.

A log of formation density can be obtained from measurements of radiation scattered from a strong source of fairly hard and monochromatic gamma rays, cobalt^{60}, for instance. The source and detector arrangement would be similar to the present commercial neutron logging instruments, with the exception of the source. Best results can be expected in small uncased boreholes.

BIBLIOGRAPHY

Anderson, H. L., "Neutrons from Alpha Emitters," *Nat. Res. Council*, Nuclear Sci. Ser., Prelim. Rep. 3 (Dec., 1948).

Bell, P. R., and Jordan, W. H., *Phys. Rev.*, 79 (1950) 392–393.

Evans, R. D., and O. R., "Studies of Self-Absorption in Gamma-Ray Sources," *Rev. Mod. Phys.*, 20 (1948) 305–326.

Fearon, R. E., "Gamma-ray Well Logging," *Nucleonics* 4 (1949) 67–75.

Hirschfelder, J. O., Magee, J. L., and Hull, M. H., "The Penetration of Gamma Radiation Through Thick Layers, I. Plan Geometry, Klein-Nischina Scattering," *Phys. Rev.*, 73 (1948) 852–862.

Hornyak, W. F., and Lauritsen, T., *Rev. Mod. Phys.*, 20 (1948) 191–227 (See p. 204).

Lind, D. A., Brown, J. R., and DuMond, J. W. M., "A Precision Determination of the Energy of the 1.1 and 1.3 Mev Gamma Radiations from Co^{60} by Direct Crystal Diffraction," *Phys. Rev.*, 76 (1949) 591.

Pontecorvo, Bruno, "Neutron Well Logging," *Oil and Gas Jour.*, 40 (1941) 32–33.

Tittle, C. W., Faul, H., Secrest, L., and Goodman, C. "Nuclear Shielding Studies, I. The Slowing Down and Diffusion of Neutrons in Hydrogenous Media," *Lab. for Nuclear Sci. and Eng.*, M.I.T., Tech. Rept. No. 21 (August 31, 1949).

Wilson, Richard, "Neutron Capture γ-rays from Cd, Cl, and C," *Phys. Rev.*, 80 (1950) 90–91.

PATENTS

O. F. RITZMANN*

ELECTRICAL PROSPECTING

U. S. No. 2,527,559. A. R. Lindblad, J. D. Malmqvist and G. V. A. Gustafsson. Iss. 10/31/50. App. 5/3/50. Assign. Bolidens Gruvaktiebolag.

Method of Geophysical Exploration. An electromagnetic prospecting system in which the transmitter coil is energized with a saw-tooth or square-wave current and the emf picked up by the detecting coil is observed on a c-r tube with time sweep.

U. S. No. 2,531,088. R. R. Thompson. Iss. 11/21/50. App. 10/16/47. Assign. Standard Oil Development Co.

Electrical Prospecting Method. A continuous electrical profiling system for use in water-covered areas in which a boat tows a multi-conductor cable having two current electrodes and a series of intermediate potential electrodes, each electrode being attached to a buoy which holds it slightly off bottom when the cable is in motion.

MAGNETIC PROSPECTING

U. S. No. 2,535,068. E. A. Johnson. Iss. 12/26/50. App. 9/6/41.

Submarine Detecting Device. A magnetic gradiometer having two search coils connected in opposition to a fluxmeter whose indicator reflects a light beam onto photocells which control relays.

SEISMIC PROSPECTING

U. S. No. 2,526,608. G. B. Loper. Iss. 10/17/50. App. 3/27/45. Assign. Socony-Vacuum Oil Co., Inc.

Gain Control System for Seismographs. An avc circuit for seismograph amplifiers in which the control tube is biased beyond cut-off and the peaks of large signals render the tube conductive.

U. S. No. 2,528,885. C. E. Hendricks. Iss. 11/7/50. App. 7/3/48. Assign. Century Geophysical Corp.

Automatic Volume Control Circuit. An avc circuit for seismograph amplifiers in which the output signal is rectified and applied as plate voltage to a triode which grounds a pair of rectifiers connected across the amplifier input with a series resistor between the amplifier and the geophone.

U. S. No. 2,532,911. R. L. Henson, Jr. and J. W. Millington. Iss. 12/5/50. App. 12/3/47. Assign. Sun Oil Co.

Drive for Seismographic Record Strips. A recorder whose record strip is driven at constant speed by a synchronous motor supplied with a-c from a vibrating-reed inverter whose frequency is controlled by a tuning fork.

U. S. No. 2,533,249. R. L. Henson, Jr. Iss. 12/12/50. App. 2/4/47. Assign. Sun Oil Co.

Seismic Detector. An electromagnetic type seismometer having an annular magnet with top and bottom air gaps in which are suspended two mechanically-connected coils whose induced emfs add but whose stray-field pickup cancels out.

U. S. No. 2,535,220. G. M. McGuckin. Iss. 12/26/50. App. 12/10/46. Assign. Socony-Vacuum Oil Co., Inc.

Apparatus for Solving Seismic Problems for Location and Dip of Reflecting Beds. A device for plotting reflecting beds and having adjustable arms with time-depth scales and which may be pivoted at the datum points.

* Gulf Oil Corporation, Patent Department.

U. S. No. 2,535,348. A. J. Z. Caan. Iss. 12/26/50. App. 3/8/49. Assign. Socony-Vacuum Oil Co., Inc.

Optical Recording Apparatus for Seismic Waves. An optical system for reproducing seismic records by scanning and having a distortion lens which converts the record in terms of time to a record in terms of depth.

WELL LOGGING

U. S. No. 2,524,031. J. J. Arps. Iss. 10/3/50. App. 10/1/45.

Apparatus for Logging Wells. Apparatus for electric logging while drilling having a turbine-driven d-c generator in the drill stem connected to two electrodes in series with a d-c motor driving an a-c generator whose output operates an acoustic signal generator in contact with the drilling fluid so that the frequency can be detected at the surface.

U. S. No. 2,524,150. R. P. Vincent. Iss. 10/3/50. App. 8/31/48. Assign. Stanolind Oil and Gas Co.

Well Logging Apparatus. A well flow meter having platinum resistance elements in a Wheatstone bridge circuit whose unbalance is automatically corrected by a motor-driven rheostat which carries the recording stylus.

U. S. No. 2,524,360. W. L. Russell. Iss. 10/3/50. App. 12/13/46.

Method and Apparatus for Well Logging. A magnetic logging system in which the horizontal component and dip angle are separately measured with a motor-driven earth inductor coil and a flux-valve direction indicator.

U. S. No. 2,524,933. D. Silverman. Iss. 10/10/50. App. 3/26/46. Assign. Stanolind Oil and Gas Co.

Interface Locator. A method of locating the interface between a conducting and a non-conducting fluid in a well by oscillating an electrode through the interface and determining its location by the ratio of signal-on to signal-off time.

U. S. No. 2,526,857. P. E. Chaney. Iss. 10/24/50. App. 6/10/49. Assign. Sun Oil Co.

Method for Logging Wells. A method of determining changes in chloride-ion concentration of drilling mud by adding phosphates to the mud so that the pH is between 7 and 9.5, and measuring the potential difference between a reference electrode and a silver electrode immersed in the mud.

U. S. No. 2,527,170. P. S. W lliams. Iss. 10/24/50. App. 4/5/47. Assign. Standard Oil Development Co.

Method and Apparatus for Detecting Corrosion. A device for detecting corrosion in pipe and having a permanent magnet and armature close to the pipe rotated in a horizontal plane about the axis of the pipe, the emf generated in a coil about the armature being recorded as the device is lowered through the pipe.

U. S. No. 2,528,882. J. T. Hayward. Iss. 11/7/50. App. 11/24/45.

Method of Logging Wells. A method of determining the depth of mud contamination by modulating the drilling rate so as to vary the concentration of the contaminant in the mud stream and analyzing the mud return at the surface.

U. S. No. 2,528,955. J. T. Hayward. Iss. 11/7/50. App. 9/19/47.

Radio-Activity Logging of Wells. A radioactivity mud-logging system in which the cuttings are separated from the mud and the radioactivity of the cuttings measured.

U. S. No. 2,530,971. C. H. Kean. Iss. 11/21/50. App. 7/26/47. Assign. Standard Oil Development Co.

Acoustic Well Logging Apparatus. An acoustic impedance logging apparatus having a magnetostrictive transducer which produces a cylindrically symmetrical wave whose wave length is longer than the diameter of the borehole.

U. S. No. 2,534,632. A. L. Smith. Iss. 12/19/50. App. 9/20/41 and 3/29/48.

Well Surveying Device. A caliper logging apparatus in which the caliper arms vary a resistance or inductance contained in a chamber sealed at the top but into the bottom of which well fluid may enter to establish pressure equilibrium in the chamber.

U. S. No. 2,535,666. R. A. Broding. Iss. 12/26/50. App. 1/24/49. Assign. Socony-Vacuum Oil Co., Inc.

Electrical Logging System. A well-logging system having in the well a long inductance connected in an a-c bridge circuit whose unbalance is analyzed at the surface for the resistive component and the inductive component.

MISCELLANEOUS

U. S. No. 2,524,934. D. Silverman. Iss. 10/10/50. App. 11/30/46. Assign. Stanolind Oil and Gas Co.

Elevation Recording Apparatus. An elevation-recording apparatus mounted in a vehicle and in which pendulum errors due to acceleration of the vehicle are corrected by having a generator driven proportional to vehicle speed connected to a dynamometer whose indication is subtracted from the elevation indication.

U. S. No. 2,526,326. J. T. Callahan and J. D. Lahmeyer. Iss. 10/17/50. App. 12/23/48. Assign. Industrial Nucleonic Devices.

Method of Geophysical Prospecting. A radioactivity-prospecting system in which the radiation energy is measured with the detector unshielded and also with the detector shielded from the ground and the difference plotted.

U. S. No. 2,531,083. A. L. Smith. Iss. 11/21/50. App. 10/16/44.

Core Analysis. A core analysis method in which the core is received in a flexible container filled with liquid and the core afterward broken or crushed so that the fragments are washed by the liquid and analyzing the liquid.

U. S. No. 2,534,737. W. D. Rose. Iss. 12/19/50. App. 6/14/47. Assign. Standard Oil Development Co.

Core Analysis and Apparatus Therefor. A core-testing apparatus in which one or more cores are held against a cellophane membrane and the cores subjected to pressure of a displacing fluid and the pressure measured on the other side of the membrane.

U. S. No. 2,535,066. G. Herzog. Iss. 12/26/50. App. 3/9/48. Assign. The Texas Co.

Prospecting. A radioactivity-prospecting system in which the gamma-ray intensity is measured and the individual rays due to cosmic radiation cancelled out by one or more shielded counters in an anti-coincidence circuit.

SELECTED LIST OF U. S. PATENTS ISSUED DURING THE FOURTH QUARTER OF 1950

Patent No.	*Subject*	*Patent No.*	*Subject*	*Patent No.*	*Subject*
2,524,031[a]	116, 208	2,524,290	168	2,524,433	224
2,524,050	68	2,524,295	316	2,524,478	460
2,524,063	224	2,524,296	316	2,524,570	92
2,524,150[a]	116, 148	2,524,297	484	2,524,579	440
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REVIEWS

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MARINE GEOLOGY, BY PH. H. KUENEN

Marine Geology, by Ph. H. Kuenen, John Wiley & Sons, Inc., New York, 1950, 568 pp.

"Marine Geology" might better be entitled "Geology"; so extensively is the subject covered. Nor is this surprising when one considers that the major contributions to geologic history have been marine rather than continental. The preponderance of marine over land area, the preponderance of marine over continental sediments are foremost examples.

Geology, then, is studied under eight chapters which are slightly reworded in the list below in order to embrace the author's main and sub-titles in one heading:

Chapter 1. Physical Oceanography
2. The Shapes & Evolutions of Sea Basins
3. The Indonesian Deep-Sea Depressions
4. Sources and Transportation of Marine Sediments
5. The Formation of Marine Sediments
6. Coral Reefs
7. Submarine Valleys and Volcanic Slopes
8. Eustatic Changes of Sea Level

Chapters 1, 4, and 5 are concerned with the general problem of sedimentation and Chapter 6 with a special aspect, coral reefs, which is of especial importance to petroleum geologists at the moment. The material on the fundamental subject, sedimentation, is the most rewarding subject matter in the volume. The complete depositional cycle (erosion at the source, transportation, and deposition) is discussed from the vantage point of a geologist who has personally witnessed and studied the phenomena during a lifetime of oceanographic research. Each phase of the cycle is meticulously described and the descriptions are dependent on a wealth of experimental and observational data.

The primary purpose of a course in sedimentation is to enable the geologist to reconstruct the paleo-environment of a rock sample. The net result of the course is, moreover, an awareness of the complexity of the problem of reconstruction. Kuenen develops the investigations to a point where he can prepare a master table, "The Marine Environment," which is the most important single unit of information presented. The marine sediments are classified with respect to both the depth of water in which they were laid down and the distance from source. Also included are the factors affecting deposition, i.e., light, temperature, salinity, and movement; and the types of source, i.e., flora, fauna, lithosphere, evaporation, and precipitation. The sedimentary classification is repeated here, especially since it is a concise grouping.

Shallow water, beach and shelf deposits: Sand, silt, clay, limestone, dolomite, reef rock, oolites, black (organic) mud.

Bathyal, slope deposits: Blue, red, green, volcanic and coral mud.

Abyssal, deep basin deposits: Calcareous and siliceous oozes, red clay.

The types are transitional and may be completely transposed. The anomalous types form the material for some of the more interesting discussions. For example, oceanographic cores have repeatedly recovered fine "beach" sands from the first few feet of sediments now underlying the ocean deeps. These sands are the cause of much speculation ranging from extreme vertical movement to powerful tsunamis. Kuenen advocates turbidity currents, hydraulic currents loaded with material in suspension, for the transportation of near shore types to the deep seas. He has conducted laboratory experiments to verify this type of flow and accepts it as an important and not as an anomalous mode of transportation.

Another seemingly anomalous type, coarse detritus on the off-shore edge of continental shelves, is explained straightforwardly. The surface of the shelves is wave controlled, and the large ocean swells, oscillatory waves, are able to remove the finer materials. The forces of these swells are attenuated at the outer edge by the restriction of the oscillatory movement and the resultant shortened waves no longer erode until approaching the coast.

The large scale variations in the production of lime throughout geologic time are of unusual interest. The pre-Cambrian is notable for the absence of organisms secreting lime whereas the Paleozoic is marked by abundant secretions in shallow water. Limestone is at peak abundance in Cretaceous sediments, but during Cretaceous time "pelagic Foraminifera began to extract large quantities of lime from the oceans and deposit their tests in the deep sea." Thus the Paleozoic and Mesozoic deposits are gradually being removed to the deep seas. This is permanent removal, by the way, as Kuenen believes in the permanency of ocean basins.

The discussion on coral reefs is not noteworthy for new contributions if one has kept abreast of recent literature but is an excellent assemblage for those who have not. The role of topographic eminences in providing reef foundations is of particular interest to geophysicists who can well utilize any anomalous forms that might initiate the stratigraphic buildup of a reef. The coral reef studies also include a strong support of the Darwinian Theory of atoll formation which is only slightly modfied to include the effects of eustatic changes in sea level resulting from glaciation. At the conclusion of Chapter six, one questions whether the author should recognize the present indulgement in reefs by including a separate chapter on this stratigraphic type without devoting similar space to equally important stratigraphic types, large sand lenses, for one example.

The remaining four chapters are concerned with the shape and evolution of marine features (basins, troughs, valleys, volcanoes, trenches) and with eustatic movements. The descriptive material on shape is easily appreciated. This naturally leads to the second phase, the evolution of these features. The proposals of origin are well received also. There appreciation ends for the author is given to lengthy presentations of everyone's theory of origin. This is of historical interest but not of genuine scientific value because many of the former theorists hardly had even meager evidence in support of their speculations. Kuenen has, of course, the most recent geologic results at hand and can also benefit by the mistakes of his predecessors. "Marine Geology" is consequently burdened with argument instead of simply stating conclusions entirely in accord with the facts presented. Wegener's well known hypothesis of floating continents appears more than once, for example, and is belabored at length, both pro and con. This is surprising to younger geologists who wonder why such conjecture is revived. Again, the origin of the Indonesian depressions appears with a complete historical review. Umbgrove deals exhaustively with the same subject in "The Pulse of the Earth" and it is highly questionable whether it should appear here except as an illustration of an important type of marine structure and sedimentary environment.

"Marine Geology" is an agglomeration of subject matter ranging from the creation of the earth to the intricate fabrication of a coral reef. This stems from an attempt to include all the material related to the main thesis no matter how indirect the relationship. The book is therefore not a well-knit unit. It is an important collection of facts and ideas brought up-to-date and is certain to become an outstanding source book. It may be selectively read for a clearer insight into the processes of sedimentation and those portions should be mastered by every geologist of sedimentary rocks.

NELSON C. STEENLAND

WORLD GEOGRAPHY OF PETROLEUM, EDITED BY WALLACE E. PRATT AND DOROTHY GOOD

World Geography of Petroleum, edited by Wallace E. Pratt and Dorothy Good, American Geographical Society Special Publication no. 31. Princeton University Press, 1950.

This attractively printed and profusely illustrated volume considers the petroleum industry from the point of view of the geographer, whose approach must coordinate geological and physiographic factors with political and economic considerations. In addition to presenting data on the location of known and potential oil fields throughout the world, this book deals with natural features, such as climate and topography, which bear on the ease with which the oil can be removed from the ground and transported to refineries and markets; it also discusses transportation facilities, trade conditions, and political circumstances which affect the distribution and use of the petroleum products ultimately derived from oil deposits in the ground.

The book consists of 23 articles solicited by the editors from 20 contributors, all prominent in their fields. The articles are grouped into four major divisions. The first, on Petroleum in the Ground is essentially a summary of the principles of petroleum geology and of geophysical and other exploration methods. The second, entirely under the authorship of W. B. Heroy, is entitled The Functional Organization of the Petroleum Industry and deals briefly with development, production, storage, transportation, refining and distribution. Part III is on The World's Petroleum Regions and deals with the oil statistics, politics and economies of all the important oil producing nations, as well as with areas, such as the polar regions and the continental shelves, where it is hoped that there is much oil still to be discovered. Part IV, on Aspects of Utilization, concentrates on the economics of petroleum consumption both for peace and war.

The diagrams and maps as well as the many full page photographs are both useful and artistic. The American Geographical Society is to be complimented for a publication that should find widespread use throughout the petroleum industry as well as among military planners and economists outside the industry.

MILTON B. DOBRIN

PRINCIPLES OF SEDIMENTATION, BY W. H. TWENHOFEL

Principles of Sedimentation, 2nd Edition by W. H. Twenhofel, McGraw-Hill Book Company, New York, 1950.

The study of sediments and the processes by which they are formed constitutes a branch of geology that is of particular interest to the exploration geophysicist. Although sedimentation has been a major field for geological investigation since the turn of the century, it was not until 1925 that the first comprehensive book on the subject appeared. This was the *Treatise on Sedimentation* by Prof. Twenhofel and a number of collaborators, an exhaustive but not too well organized reference work covering all significant developments up to that time. A revised edition appeared in 1932. Twenhofel subsequently condensed the material in the "Treatise" and adapted it for classroom study, publishing this version in 1939 under the title *Principles of Sedimentation*. The current edition was prepared, according to the author's preface, to bring the material up to date by incorporating the numerous contributions to the subject made since 1939.

As in the previous edition, Twenhofel gives major emphasis to the environmental factors governing the production, transportation, deposition, and subsequent modification of sediments. His discussion of these factors is illustrated mainly by reference to sedimentary processes now going on that are observable in the various environments. Much more attention is given to sediments and sedimentation than to sedimentary rocks; this approach gives the book its unique character.

The first six chapters include discussions of the various environmental factors as well as the origin, transportation and deposition of sediments. The remaining nine chapters are concerned with the sediments themselves. One chapter of about 60 pages covers the clastic sediments while five chapters,

requiring almost 200 pages, are needed to treat sediments of chemical deposition such as limestones, dolomites, coals, evaporites and cherts. A wealth of facts and figures on these topics is reproduced from the world's literature.

There are many instances, unfortunately, where the reference material is presented in such undigested form that the reader may be left confused. This is particularly noticeable in discussions of controversial points where a great deal of evidence is presented on both sides without sufficient summing up of the case or evaluation of the arguments.

Although the purpose of the new second edition was to present the developments of the past decade, discussion of much important work done during this period is surprisingly sketchy. No reference is made to the statistical techniques for analyzing and describing sediments which have been developed by such workers as Krumbein and Trask. A long section on chert and its origin makes only passing acknowledgment of the 1946 paper by Bramlette, considered by many specialists in this field as a definitive contribution to the subject. Density currents (now generally referred to as turbidity currents) are discussed briefly but with no mention of the important recent contributions of Natland and Kuenen. There is little specific reference in the discussion of marine sediments to the numerous bottom cores and samples obtained during and since World War II in many oceanic areas. To consider one last example, the treatment of reefs refers to very few of the many publications on the subject that have been stimulated by the Bikini expedition and the recent recognition of reefs as an important source of oil.

In spite of these omissions, which are well supplied in other recent books on sedimentary rocks and on marine and submarine geology, Twenhofel's text still surpasses all others on the subject in presenting sedimentation as a contemporary and ever continuing process rather than one associated primarily with the geologic past.

MILTON B. DOBRIN

GEOPHYSICAL INVESTIGATIONS IN THE EMERGED AND SUBMERGED ATLANTIC COASTAL PLAIN, PART V: WOODS HOLE, NEW YORK AND CAPE MAY SECTIONS, BY MAURICE EWING, J. L. WORZEL, N. C. STEENLAND, AND FRANK PRESS

"Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain, Part V: Woods Hole, New York and Cape May Sections," by Maurice Ewing, J. L. Worzel, N. C. Steenland, and Frank Press. *Bull. Geol. Soc. Am.*, vol. 61, pp. 877–892 (1950).

Dr. Ewing and his associates have pioneered in the application of the refraction seismograph to the study of submarine geology. In this paper, the latest of a series of reports, the first of which appeared in 1937, results are given of shooting on three lines or sections across the continental shelf. The sections extend south from Woods Hole, Mass., southeast from Fire Island, New York, and southeast from Cape May, New Jersey; the latter is an extension of a section previously shot across the coastal plain in New Jersey.

The Woods Hole section shows the surface of the high velocity medium, identified as crystalline basement, sloping gently seaward with a dip of about 0.5°, out to about 60 nautical miles south of the coast, where the dip increases to 1° for the remaining 25 nautical miles. The depth to the basement at the end of the profile is calculated to be about 5,000 feet. Throughout most of the profile only one layer is recognized above the basement; this has a velocity at about 6,000 ft/sec, and by analogy with previous work on the coastal plain is believed to consist of unconsolidated sediments of post-Raritan age.

On the Fire Island (New York) section the basement slopes gently out to a point about 20 miles south of Fire Island, where it is 2,700 feet deep, and then plunges to a depth of 16,000 feet in the next 28 miles; from there on it becomes somewhat shallower, with undulations. Southward from the point where the slope increases the basement is overlain by a layer of intermediate velocity (10,880–11,900 ft/sec) which is interpreted as consisting of semiconsolidated sediments of pre-Magothy age

(i.e. lowermost Upper Cretaceous and older). This is overlain by the low-velocity layer (5,200–6,100 ft/sec), which has a maximum thickness of 3,900 feet at the seaward end of the profile and thins northward at a nearly uniform rate. North of the point where the basement slope increases this low-velocity or unconsolidated layer rests directly on the basement.

On the Cape May section a similar increase in the basement slope appears, but here the break is only a few miles off the coast. On this section the maximum depth of the basement (or high-velocity medium) is calculated to be 17,200 feet at a point about 25 miles north of the edge of the shelf; and the depth decreases to about 14,000 feet at the edge of the shelf. As in the New York section the basement is overlain by a layer of intermediate velocity (10,100–14,200 ft/sec) but in this case the intermediate layer extends northward of the break in basement slope, for it was recognized on the earlier section across the coastal plain in New Jersey. The low velocity layer, as in the New York section, increases at a fairly uniform rate and reaches a maximum thickness of 4,750 feet near the edge of the shelf.

It will be recalled that in the earlier work off Fort Monroe, Virginia, which was reported in 1937, Dr. Ewing and his associates found a steepening of the basement slope a few miles off the coast, attended by a great increase in thickness of the semi-consolidated layer. Because of a shortage of explosives, data at the outer end of the line were inconclusive, but using a reasonable assumption regarding basement velocity it was calculated that the depth of the basement at the edge of the shelf was about 12,000 feet. This was about twice the depth that would have been predicted by projecting the basement slope as it was then known from the existing wells on land, and so far as the reviewer knows it was the first evidence of any kind that there might be a thick section of beds older than the Upper Cretaceous present on the continental shelf. There is no doubt that this discovery gave a considerable stimulus to petroleum exploration on the eastern edge of the coastal plain, for it suggested that wells drilled near the coast in some areas might encounter beds of greater thickness and of a more favorable facies than were known in outcrop or from previous wells.

Subsequent drilling, while it did not find oil, did substantially confirm Ewing's interpretation of the Fort Monroe profile in that it showed an increase of basement slope near the coast, both in North Carolina and in Maryland, and revealed the presence of a considerable thickness of beds older than the Upper Cretaceous. The Hatteras well was drilled through 9,878 feet of sediments before entering the crystalline basement, which was at least twice the thickness that would have been predicted by projecting basement dips from known wells. The lower 5,400 feet of this section is of pre-Magothy age, and may include sediments older than the Lower Cretaceous.

Refraction data of the Esso Standard Oil Co. in the vicinity of the Hatteras well suggest that the high velocity refractor may in some cases be something higher than the true basement. From the calculated depths to a refracting horizon of 19,400 ft/sec velocity it was first predicted that the well would enter basement at 8,200 feet. After the well was drilled, it was apparent that the high velocity refractor was not the crystalline basement, but a limestone-dolomite in the interval 8,515 to 9,150. The reviewer believes that the "basement" depths on Ewing's profiles, particularly on the deeper, seaward portions, should be regarded as minimum depths, and that the true basement may in some cases be deeper than the refraction data indicate.

There is a strong similarity between the condition in North Carolina, revealed by the refraction data of the Esso Standard Oil Co., and that shown by Ewing's New York section, in that where the basement is shallow and gently sloping a single layer, of velocity 5,400–7,400 ft/sec was identified above the basement, whereas east of the line along which the high velocity surface steepens an intermediate layer of 8,300–10,500 ft/sec velocity was recognized.

The work reported in the present paper, together with the earlier reports and the results of drilling in North Carolina and in Maryland, give a rather coherent picture of a basin on the continental shelf of sediments mostly pre-Upper Cretaceous in age, reaching a depth of at least 17,000 feet in some parts (and possibly more, if limestones and dolomites are present) and shallowing rather abruptly on the landward side. The zone of steepening of the basement slope, and thickening of the older sediments appears to run through Pamlico Sound, east of Fort Monroe, through eastern Maryland, just

off the coast at Cape May. Identified about 20 miles off the coast south of Long Island, it does not appear to extend as far north as Cape Cod.

The data for the three sections presented in the present paper are far more complete than those obtained in the earlier ocean work, largely because the authors were able to fire more shots and to extend their profiles to greater distances. Each section consists of a number of connected refraction profiles averaging about fifteen miles in length. Examination of the time-distance graphs shows that apparent velocities are well determined. For some of the reversed station pairs the data indicate a change of slope within the interval between the two stations, and since the coverage is not complete on the refracting horizon, the authors have had to make an assumption regarding the point at which the break occurs. It seems to the reviewer that this is fully justified in reconnaissance work of this kind; comparable assumptions are usually made in commercial reconnaissance work, and sometimes cannot be avoided even in detailed work.

The paper is well illustrated with reproductions of typical records, travel-time curves, and sections showing the geological interpretation. There is also a map showing structure contours on the basement, as deduced from both refraction and well data. The reviewer believes that most geophysicists and geologists will find this paper of considerable interest, and will look forward to the publication of further results of Prof. Ewing's off-shore shooting program. Few research projects of the last twenty years have yielded as much geological information as has this marine seismograph work, and the authors are to be congratulated for having developed techniques by which the geological structure of large areas of the earth's surface, at present completely unexplored, may eventually be worked out.

D. C. Skeels
Standard Oil Co. (N.J.)

SOME PROBLEMS OF THE PROPAGATION OF ELASTIC WAVES IN A HORIZONTALLY STRATIFIED MEDIUM, BY C. Y. FU

"Some Problems of the Propagation of Elastic Waves in a Horizontally Stratified Medium," by C. Y. Fu. *Journal of the Chinese Geophysical Society*, Vol. 2, pp. 40–60 (June, 1950).

The author treats some general problems illustrating the similarity between plane waves and cylindrical waves having axial symmetry. In this connection he emphasizes the need for Sommerfeld's conditions at infinity as arising in the latter case because of the existence of sources, whereas plane wave treatments assume all sources at infinity. Following this general introduction, the author presents some pertinent remarks on three specific problems: (1) the usually neglected roots of the Rayleigh wave equation; (2) surface waves having axial symmetry; and (3) waves in a horizontal lamina.

In discussing the Rayleigh wave problem, the author takes the general point of view in his derivations and seeks waves which produce zero stress at the free surface and which are either attenuated with increasing depth or unattenuated and travelling away from the free surface. Except for the questions raised by Dix[1] regarding the second assumption, these appear to be general enough and sufficiently valid. The solutions of this problem are three-fold. The one representing damping with depth is, of course, the usual Rayleigh wave. The other two are body waves which simply satisfy the boundary conditions. The author discusses these in detail for the case of a Poisson solid (i.e. $\lambda=\mu$).

In treating surface waves with axial symmetry, the author discusses both Rayleigh waves and Love waves. In both cases he indicates the type of differences from plane wave solutions to be expected near the source. Of course, this can be done only in a general manner unless one specifies the type of source—a difficult problem in most seismological cases.

Finally, the treatment of waves in a horizontal lamina proceeds from the case of a lamina with two free surfaces to one embedded in a fluid and finally to one embedded in another solid. The latter solution is only indicated in rough form since this, in the most interesting cases, is a suitable subject

[1] C. H. Dix, *Geophysics*, 15, 447 (July, 1950).

for several research papers. It is shown in a formal way how the modes of vibration of the free lamina are gradually modified by this immersion into media more nearly like the lamina itself.

W. JACQUE YOST
Magnolia Petroleum Co.

AEROMAGNETIC SURVEY OF PARTS OF BARAGA, IRON AND HOUGHTON COUNTIES, MICHIGAN, WITH PRELIMINARY GEOLOGIC INTERPRETATION, BY J. R. BALSLEY, H. L. JAMES, AND K. L. WIER

"Aeromagnetic Survey of Parts of Baraga, Iron, and Houghton Counties, Michigan, with Preliminary Geologic Interpretation," by J. R. Balsley, H. L. James, and K. L. Wier. Geophysical Investigations Sheet, Geological Survey, U. S. Department of the Interior (1949).

During 1947 and 1948 the U. S. Geological Survey, in cooperation with the Geological Survey Division of the Michigan Department of Conservation, made an airborne magnetometer survey of an 800-square-mile area lying southwest of the Keweenaw Peninsula between Otter Lake and the Brule River, Michigan. This was part of a large-scale survey covering some of the iron districts in Michigan. Most of the surveyed area is covered with a mantle of glacial drift, and very few outcrops are to be found. The magnetic rocks known to exist within the bedrock of the area include magnetic "slates" of probable volcanic origin, basaltic "trap rocks" (Keweenawan), and diabase dikes; all of these rocks are pre-Cambrian in age. The measurements were made with a continuous-recording AN/ASQ-3A airborne magnetometer installed in a Beechcraft AT-11 airplane. North-south traverses were flown approximately 500 feet above the ground at quarter-mile intervals. A chart accompanying the paper gives the magnetic profiles of 48 traverses, each of which represents a flight distance of 50 to 65 miles.

The dominant feature of the profiles is the persistent easterly trend of essentially all of the major anomalies. In the northern part of the surveyed area sharp negative anomalies, several hundred gammas in magnitude, persist in an easterly direction for several miles. These negative anomalies are caused by steeply dipping or vertical diabase dikes, outcrops of which have been found amid the glacial drift by ground geological parties. The largest of these negative anomalies, overlying a diabase dike known to be at least 150 feet wide in places, persists in an easterly direction for more than 13 miles. Most of the diabase dikes that produce anomalies in the surveyed area are marked by negative, rather than positive, anomalies, the negative character being attributed by the authors to inverse remanent magnetization. The authors state that insofar as it can be determined at present, the inverse remanent magnetization is *not* due to tilting of dikes originally magnetized in the direction of the present geomagnetic field.

In the central part of the surveyed area pronounced positive anomalies are caused by magnetic slates striking east. In the case of one of these anomalies it is possible to postulate, on the basis of geologic evidence used in conjunction with the diminution and broadening of the anomaly in a westward direction, that a westward-plunging anticline exists in the Michigamme slate. In the extreme northern part of the surveyed area predominantly positive anomalies are probably caused by "traps" of Keweenawan age. In the southern part of the area strong positive anomalies are related to greenstones and magnetic slates.

Except in one area, where structural and magnetic complexities limit the value of the survey, the authors find good correlation of the magnetic data with the known geology. The aeromagnetic survey, because of the persistence of many of the anomalies, provides a framework into which can be fitted the scattered data afforded by the few outcrops and by drill cores. The scattered geologic data can be related to the observed magnetic trends, which can then be used to indicate the trends of the geologic structure.

KENNETH L. COOK

AEROMAGNETIC SURVEY OF THE ALLARD LAKE DISTRICT, QUEBEC, BY WESTON BOURRET

"Aeromagnetic Survey of the Allard Lake District, Quebec," by Weston Bourret. *Economic Geology*, Vol. 44. Pp. 732–740 (December, 1949).

During 1947 an aeromagnetic survey over ilmenite-hematite deposits in eastern Quebec was made by Aero Service Corporation with magnetometer and recording equipment manufactured and licensed by the Gulf Research and Development Company. The surveyed area, containing literally hundreds of small lakes and many streams, is difficult of access. Pre-Cambrian rocks, which underlie the entire surveyed area, are well exposed except over certain broad slopes and swampy areas covered with glacial deposits. A large mass of anorthosite, trending in a northeasterly direction for a distance of 90 to 100 miles, was traversed in the course of the survey.

The massive ore bodies which are found within the anorthosite occur in the form of irregular lenses, narrow dikes, large sill-like masses, or a combination of these. The larger deposits of commercial ore probably represent a late segregation or concentration product of the magma that formed the anorthosite. The massive ore consists predominantly of ilmenite (70 per cent), with crystalographic intergrowths of hematite (20 per cent) and some magnetite (3–5 per cent); the remainder is chiefly pyroxene and feldspar gangue. The ilmenite is magnetic. The largest known ore deposit in the district, which has been partly outlined by core drilling, is a gently inclined tabular body, with a vertical thickness of 100 to 300 feet and an indicated tonnage of "well over 100,000,000 tons of ore containing 32 to 35 per cent TiO_2."

More than 4,500 miles of traverse were flown approximately 500 feet above the ground alonglines spaced one-quarter, one-half, or one mile apart, the interval depending on the promise shown by the immediate area. All lines were flown on a N. 45° W. bearing in order to cross the short dimensionof the anorthosite mass.

Two aeromagnetic profiles over known ore bodies are presented in the paper. The anorthosite exhibits broad magnetic features with little relief. The author states that "in all instances" the large massive deposits gave negative anomalies amounting to 3,000 to 5,000 gammas. In each case this negative characteristic is believed "to result from the effect of negative polarization of the ore body itself." Similar negative anomalies were found over the same occurrences by a ground party using a dip-needle. The horizontal limits of certain aeromagnetic anomalies correspond rather well with the known surface position of the ilmenite bodies. The location of mapped isogams may be in error by as much as 400 or 500 feet, which is probably greater than the displacement due to the inclination of the earth's magnetic field in this area.

This aeromagnetic survey is a good example of how a regional geologic picture can be obtained rapidly and economically in a rather inaccessible region for the purpose of singling out particular areas of geological and geophysical interest for more detailed study.

KENNETH L. COOK

MAGNETIC SURVEYS IN THE IRON SPRINGS DISTRICT, IRON COUNTY, UTAH, BY KENNETH L. COOK

"Magnetic Surveys in the Iron Springs District, Iron County, Utah," by Kenneth L. Cook. *U.S. Bureau of Mines Report of Investigations 4586* (January 1950), 78 pages, 45 figures, 8 tables.

This paper is a comprehensive report of vertical magnetic surveys conducted during 1944–45 by the U. S. Bureau of Mines in the Iron Springs iron-ore district of Iron County, Utah. These surveys were made during the latter years of World War II in conjunction with strategic mineral investigations and were made with the primary purposes of (1) exploring outcropping ore bodies to determine their length, width, depth extent, strike, dip and tonnage; (2) exploring geologically favorable areas where no ore bodies outcrop in an endeavor to find new ore bodies; (3) determining favorable locations for diamond drilling, both in areas of exposed ore bodies and in areas of newly discovered

magnetic anomalies; and (4) assisting in the eventual determination of a tonnage estimate of the near-surface iron-ore reserves of the entire Iron Springs district.

The magnetic surveys were confined to the margins of three separate monzonite intrusions where most of the large iron-ore bodies occur as pods of replacement ore within a favorable limestone bed. The iron ore is a mixture of magnetite and hematite, with the magnetite content ranging from 14 to 58 per cent. Some 62,000 magnetometer stations were taken over a total traverse distance of about 300 miles. The station interval along traverses ranged from 10–100 feet and the distance between traverses ranged from 100–1,000 feet. The high magnetite content (14–58 per cent) of the ore bodies in contrast with the moderately-low magnetite content (probably less than 2½ per cent) of the monzonite and the negligible magnetite content of the sedimentary rocks provided rather ideal conditions for these magnetic surveys and produced very favorable results. Magnetic anomalies of 1,250 gammas or more were usually found over the near-surface ore bodies.

Core drilling at 36 holes aggregating 15,489 feet was well coordinated with the magnetic program. The core drill data gave helpful correlation of the geology and geophysics and served to check the qualitative interpretation and prior quantitative estimates. Forty-five separate magnetic anomalies indicating the possible existence of ore bodies were observed. Of these, 13 anomalies are caused by outcropping ore bodies of proved commercial size. Five were caused by non-outcropping ore bodies of proved commercial size which were discovered, in whole or part, as a result of the geophysical surveys. Of the remaining anomalies, which lie in virtually untested areas where few or no ore bodies are exposed, six are probably caused by large, unexposed replacement ore bodies, nine are possibly caused by such bodies, and six are probably caused by unexposed magnetite veins of small commercial importance.

A thorough and well organized discussion is presented of the geology, factual magnetic data, magnetic surveys, theoretical considerations used in the interpretations, qualitative and quantitative interpretations, results of drilling and other aspects of the work. The text is accompanied by numerous maps and several profiles and tables.

JACK W. PETERS
Magnolia Petroleum Company

THE REGIONAL GEOPHYSICS OF WESTERN HUNGARY, BY V. SCHEFFER AND K. KANTAS

"The Regional Geophysics of Western Hungary," (in Hungarian) by V. Scheffer and K. Kantas, *Bull. Hungarian Geological Soc.*, Vol. 79, pp. 327–360 (1949).

This paper demonstrates how the results of regional geophysical surveys in Hungary west of the Danube River show a very marked agreement with the known geology of the area and how they indicate, in addition, the still active orogenic forces inside the crescent of the Carpathian Mountains. The western part of the Carpathian Basin is diagonally transsected from the southwest by the Yugoslav-Austrian-Hungarian border to the big bend of the Danube above Budapest and northeastward by a series of small igneous and Mesozoic complexes. This line, marked by the trend of Lake Balaton, constitutes a geomorphic, as well as a structural unit, and can be conceived as a geological "Hinge Line."

The regional gravity anomalies of the Transdanubian area, based on torsion balance surveys, show that the Bouguer anomaly corresponds in sign and magnitude with the isostatic anomaly. The contours of the anomaly parallel the trend of the "Hinge Line," and show a positive Bouguer anomaly, indicating that the line is rising instead of sinking. The "Hinge Line" also shows up well on the magnetic anomaly map, which indicates, in addition, a series of parallel trends, interpreted in turn as part of the "Inner Volcanic Arc of the Carpathian Mountains." The active seismicity in the Transdanubian Basin is localized along the flanks of the "Hinge Line" leaving the crest of the line as well as the basins untouched. This sheds further light on the structural function of the "Hinge Line."

A comparative study of the changes of the base reference levels of the geodetic network over a

period of 60 years shows that the contours of equal change parallel the "Hinge Line," the latter serving as a pivot about which the area northwest is rising and that in the southeast is sinking. A geothermal investigation shows that the anomaly values of the reciprocal geothermal gradients also parallel the "Hinge Line," which serves as a dividing line between the positive and negative geothermal anomalies. The article is well illustrated with German subtitles and a long German abstract, which permit its use for comparison with other regions by those not familiar with Hungarian.

MYRON T. KOZARY
Columbia University

A SONIC DEVICE FOR UNDERWATER SEDIMENT SURVEYS, BY E. C. LAFOND, R. S. DIETZ AND J. A. KNAUSS

"A Sonic Device for Underwater Sediment Surveys," by E. C. LaFond, R. S. Dietz and J. A. Knauss, *Jour. Sedimentary Petrology*, Vol. 20, pp. 107–111 (1950).

This paper describes a simple, direct adaptation of an ordinary hydrophone and its associated amplifier for rapid identification and mapping of bottom sediments. The hydrophone, a Brush Development Company C-23, is encased in a metal cylinder having ridges on its outside surface. This is dragged over the bottom, the observer listening to the sounds picked up by the hydrophone in the process. Each type of bottom sediments, such as mud, sand or stone, gives rise to characteristic sounds which enable one to chart its extent. These types are readily distinguished, and, further, in some instances it has been possible to distinguish fine, medium and coarse sand.

It is pointed out that each observer must develop his own judgment of the characteristic sounds by hearing the hydrophone dragged over known sea bottom sediments. Also, in any given survey the results of the sonic observations must be spot checked by conventional bottom sampling. A second method of obtaining similar results is to drag an empty metal cylinder along the bottom by a steel towline. A microphone attached to the towline picks up sounds transmitted up it. This method was found to be less sensitive and subject to difficulties from extraneous noises.

It would seem that almost any small hydrophone could be used practically for this purpose. Certainly any of several cylindrically shaped phones would do as well as the C-23. Amplifier requirements are not critical since the output of the hydrophone would probably be of the order of millivolts or higher. A possible difficulty lies in the dynamic range of the equipment. It would seem that excessive distortion of the sounds caused by overloading the amplifier might have the effect of warping the judgment of the observer. Probably the simplest countermeasure is an input attenuator.

A principal use of the technique is indicated to be the determination of the boundaries between different sediment types, a difficult and time-consuming project with a grab sampler. Its use is probably limited to water 100 fathoms deep or less owing to towing difficulties at greater depths. A bottom sediment survey off the California coast is described in which this method was employed.

J. B. HERSEY

NEW DIP-LOGGING METHOD, BY F. G. BOUCHER, A. B. HILDEBRANDT, AND H. B. HAGEN

"New Dip-Logging Method," by F. G. Boucher, A. B. Hildebrandt, and H. B. Hagen, *Bull. AAPG*, pp. 2007–2026 (Oct. 1950).

The authors explain how the direction and magnitude of formation dip can be determined by recording simultaneously in a bore hole three oriented profiles of the bore wall. The subsurface instrument consists essentially of a three-arm caliper and an orientation chamber; it is connected to the surface equipment by means of a three-conductor logging cable. Six signals, which supply all the data needed for determining the formation dip, are continuously transmitted on the logging cable and recorded at the surface.

A substantial part of the paper discusses in a very objective manner the reproducibility of the results and the accuracy obtainable. The method seems to be reasonably accurate when dips are greater than about 5°. For small dips, the direction of strike should not be relied on unless several determinations substantiate one another. This reviewer finds many similarities and some differences between the method described and the Potential Dipmeter method. The value of the paper would have been enhanced if the authors had elaborated on these points. In particular, a review of the conditions under which the new method may be superior to the other would have been most instructive.

HUBERT GUYOD
Houston, Tex.

NEW METHOD OF CORRELATION BY RESISTIVITY VALUES OF ELECTRICAL LOGS, BY A. CLAUDET

"New Method of Correlation by Resistivity Values of Electrical Logs," by A. Claudet, *Bull. AAPG*, pp. 2027–2060 (Oct. 1950).

This paper explains how correlations of electric well logs can be made easier and/or more accurate by using the shale resistivity value in addition to the graph silhouette. The author has found that shales exhibit significant resistivity changes both horizontally and vertically, and that these changes are usually consistent over large areas. This may permit making better correlations not only regionally but also locally, for instance in faulted fields. The author points out also that in certain areas there are vertical cyclical variations in shale resistivity values and that these variations seem to be related to geological phenomena such as transgressions and regressions. The paper includes a large number of correlation sections throughout Louisiana, Mississippi and Alabma.

This reviewer finds that the examples given do not substantiate the author's claims very well. In many cases the illustrations actually show that the conventional silhouette correlation method gives better and easier correlations than the resistivity method. In the few examples where correlations obtained by the conventional method are difficult (either because they are actually so, or because parts of the electric logs have been suppressed) neither the illustrations nor the text explains objectively how the rather scattered resistivity values which are shown should be correlated.

It seems, nevertheless, to this reviewer that the method may be useful in certain cases and, for this reason, the paper is valuable for directing the geologists' attention to an additional tool which may have been overlooked in the past. The most promising application of the method is probably its use in geological research since, as the author justly points out, the resistivity of shales is controlled by the sedimentation process.

HUBERT GUYOD
Houston, Tex.

PUBLICATIONS RECEIVED

Listed below are all books and periodicals received at the business office on subscription and through free exchange for *Geophysics* since the last issue went to press. Titles identified by the asterisk (*) are placed in the depository of the society and are available, after review, for loan to members of the society on application to the business manager. Books and reprints of individual papers are retained by the reviewer.

Periodicals

American Journal of Science, Vol. 248, No. 12 (Dec., 1950); Vol. 249, Nos. 1 & 2 (Jan. & Feb., 1951)

**Boletin de la Asociacion Mexicana de Geologos Petroleros*, Vol. 2, Nos. 7, 8 & 9 (July, Aug. & Sept., 1950)

Bulletin of the American Association of Petroleum Geologists, Vol. 34, Nos. 11 & 12 (Nov. & Dec., 1950); Vol. 35, No. 1 (Jan., 1951)

**Bulletin of the Seismological Society of America*, Vol. 40, No. 4 (Oct., 1950)

**Canadian Geophysical Bulletin*, Vol. 4, No. 2 (1950)

**Erdöl und Kohle*, Vol. 3, Nos. 10, 11 & 12 (Oct., Nov. & Dec., 1950)

**Geofisica Pura e Applicata*, Vol. 17, No. 1–2 (Jul.–Sept., 1950)

**Geophysical Exploration* (S.E.G. of Japan), Vol. 3, Nos. 1 & 2 (1950)

Institute of Petroleum Review, Vol. 4, Nos. 46, 47 & 48 (Oct., Nov. & Dec., 1950)

Journal of Applied Physics, Vol. 21, Nos. 11 & 12 (Nov. & Dec., 1950); Vol. 22, No. 1 (Jan., 1951)

Journal of Geophysical Research, Vol. 55, No. 4 (Dec., 1950)

Journal of the Institute of Petroleum, Vol. 36, Nos. 321, 322, 323 & 324 (Sept., Oct., Nov. & Dec., 1950)

**Nafta*, Vol. 6, Nos. 9, 10–11 & 12 (Sept., Oct.–Nov. & Dec., 1950)

**Nuclear Science Abstracts*, Vol. 4, Nos. 21, 22, 23 & 24A (Nov. 15, Nov. 30, Dec. 15 & Dec. 30, 1950); Vol. 5, Nos. 1 & 2 (Jan. 15 & Jan. 30, 1951)

**Proceedings of the Cambridge Philosophical Society*, Vol. 47, No. 1 (Jan., 1951)

Review of Scientific Instruments, Vol. 21, Nos. 11 & 12 (Nov. & Dec., 1950); Vol. 22, No. 1 (Jan., 1951)

**Science Reports of the Tohoku University*, Vol. 2, No. 2 (Aug., 1950)

**Annals of the Geological Society of Poland*, Vol. 19, Nos. 2 & 3 (1949)

**Technical Data Digest*, Vol. 15, No. 12 (Dec., 1950); Index, Jul.–Dec., 1950; Vol. 16, Nos. 1 & 2 (Jan. & Feb., 1951)

**Tellus*, Vol. 2, No. 3 (Aug., 1950)

Books

How Oil is Found, W. A. Ver Wiebe (1951)

Reports of Proceedings, the Fifth General Assembly of the International Council of Scientific Unions, F. J. M. Stratton

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CONTRIBUTORS

HENRY FAUL

HENRY FAUL studied geology and physics at the Massachusetts Institute of Technology (S.B., 1941) and Michigan State College (M.S., 1942). He served as research physicist with the National Research Corporation (1942–1943); as a geophysicist with the Union Mines Development Corporation (a contractor of the Manhattan District, U. S. Engineer Corps, 1943–1946); and as staff scientist in the atomic bomb test, Bikini (1946). He returned to M.I.T. in 1947 as Research Associate in geophysics (Ph.D., 1949), and joined the U. S. Geological Survey in 1949. He is a member of Sigma Xi and the American Physical Society.

L. Y. FAUST

L. Y. FAUST was born in Clearville, Pennsylvania, in 1904. He received a B.S. degree in Physics from Franklin and Marshall College in 1925 and a Ph.D. in Physics from the University of Pennsylvania in 1930.

His geophysical experience began with the Sun Oil Company in 1926. Since 1930 he has been employed by the Geophysical Research Corporation and Amerada Petroleum Corporation, serving as a seismograph party chief until 1933 and as a geophysical supervisor since that time. His present duties are concerned with the study of special geophysical problems and seismic reinterpretation.

Dr. Faust is a member of the Society of Exploration Geophysics and American Geophysical Union.

A. E. SMITH

A. E. SMITH was graduated from the School of Mines of the University of Pittsburgh in 1924 with the degree of Petroleum Engineer. He was employed soon after by the Shell Oil Company in their Geophysical Department where he has devoted the majority of his time since in magnetic and gravimetric surveys.

Mr. Smith is a member of the American Association of Petroleum Geologists, the American Geophysical Union, the Seismological Society of America, and a charter member of the Society of Exploration Geophysicists.

C. W. TITTLE, until recently, was Professor of Physics at North Texas State College, Denton, Texas. He is now a research physicist with the Gulf Research and Development Company, Pittsburgh, Pa. Mr. Tittle received the B.S. and M.S. degrees from North Texas State College in 1939 and 1940, respectively, and the Ph.D. from Massachusetts Institute of Technology in 1948. During World War II, he taught pre-radar communications at Southern Methodist University, radar at M.I.T., and served as a second lieutenant in the Signal Corps.

C. W. TITTLE

JAMES R. WAIT was born January 23, 1924, in Ottawa, Canada. He served as a radar technician in the Canadian Army during the last war. He was graduated from the University of Toronto in 1948 in engineering physics. Following this he was employed by the Hydro Electric Power Commission of Ontario Research Laboratories. In the spring of 1949 he obtained the M.A.Sc. degree in Engineering Physics from the University of Toronto. Since that time he has been employed by Newmont Exploration Ltd. of Jerome, Arizona.

Mr. Wait is a member of the Association of Professional Engineers of Ontario.

In addition, references are cited to earlier issues for the biographies of: R. A. Geyer, Vol. XIII, No. 4 (October, 1948), p. 649; W. E. Hollingsworth, Vol. XII, No. 2 (April, 1947) p. 298.

MEMORIAL

HERMAN SHAW (1891–1950)

Dr. Herman Shaw, Director of the Science Museum, London, died suddenly at his home in Barnes, Middlesex, England on May 4, 1950.

His record as administrator, scientist and man of affairs was an impressive one and his friendliness and accessibility had endeared him to a very wide range of acquaintances.

He was born on October 14, 1891, the only son of the late Mr. G. H. Shaw of Huddersfield, Yorkshire. He was educated at Bradford Grammar School, where he obtained a Governors' Scholarship and at the Imperial College of Science and Technology, which he entered as a Royal Scholar in 1911. In 1913 he won an Aeronautics Research scholarship at this College.

In the first world war he became a Lieutenant in the R.N.V.R. in 1915, a Flight Lieutenant in the R.N.A.S. in 1916 and a Captain in the R.A.F. in 1917.

Shaw joined the staff of the Science Museum in 1920 and for the remaining 30 years of his life his energies were devoted to the development and expansion of its collections and services and to research in Exploration Geophysics.

His work in Geophysics began in 1921 when he and the late E. Lancaster Jones made extensive laboratory tests on an Eötvos Torsion Balance, which had been acquired by the Museum.

In 1925 Shaw and Lancaster Jones, using a British-made torsion balance, in the design of which they had played a leading part, carried out a gravity survey

at Hodbarrow, Cumberland, the first survey of its kind to be carried out in the British Isles. Shaw and E. Lancaster Jones designed in 1928 their "gravity gradiometer," a form of torsion balance specially modified for field work concerned with the measurement of gravity gradients. Shaw's papers on the Interpretation of Gravity Anomalies were published in 1929 and 1930.

Shaw's interest in Exploration Geophysics, while mainly concerned with the gravity method, extended to cover other aspects of this science, including the seismic method of prospecting and he published in all about 20 papers.

Concurrently with his geophysical work Shaw was very active in purely Museum work. Considerable expansion took place in the science collections, in the ten years following World War I and Shaw played his full part in this development. He was also responsible to a large extent for the special exhibition of Applied Geophysics held at the Museum in 1931 and was co-author of the Museum Handbook on the subject published at this time.

He was made a Deputy Keeper in 1931 and in 1935 Keeper of the Department of Physics and Geophysics. In 1939 he was put in charge of Air Raid Precaution arrangements at the Museum and later took full charge of the arrangements for the evacuation to the country of the greater part of the collections. It was largely due to him that collections came through the Second World War with a minimum of damage or deterioration. In 1940 he was made Acting Director of the Museun and in 1945 he succeeded Col. E. E. B. Mackintosh as Director.

Despite the burden of his normal duties Shaw found time to play a notable part in many outside activities. His association with the Physical Society of London in particular was a long and intimate one. He was elected Fellow in 1914 and was a Member of Council from 1935–39 and from 1941–46 in which year he was elected Hon. Treasurer, a position which he held at the time of his death. He was a Founder Fellow of the Institute of Physics.

At the time of his death Shaw was also President of the Museum Association, a Trustee of the Imperial War Museum and Governor of the Imperial College of Science and Technology and a Manager of the Royal Institution.

Shaw married in 1919, Constance, the daughter of Mr. F. Shaw of Harrow. They had one son, who died a young man in 1946. The loss was a severe blow to Shaw and his wife, but he bore it with fortitude and only those in close contact with him were able occasionally to realize what it had cost him.

As a man his most notable characteristics were his energy and approachability. He never spared himself in work, but obviously enjoyed the wide range of contacts which it had brought him.

His sudden death at the height of his career is a severe blow to the Museum to which he devoted so much of his energy and talents and will be deeply regretted by his large circle of acquaintances in many walks of life.

R. DAVIES

London
December 15, 1950

MEMORIAL

WILLIAM GILMORE SMILEY, JR. (1906–1950)

William Gilmore Smiley, Jr., Geophysicist for Sun Oil Company, died in his home at 2905 Westminister St., Dallas, Texas on November 8, 1950 after an illness of more than a year. His death was a great loss to his family and to a large circle of friends in the oil industry.

William G. Smiley, Jr. (Bill), was born January 22, 1906 in Houston and was the son of William Gilmore Smiley and Mary Brantly Tarrant Smiley. Mr. Smiley, Sr., was for many years county superintendent of schools in Harris County. Mrs. Smiley, Sr., has been a member of the Harris County school board for several years.

Bill Smiley attended Rice Institute at Houston from 1923 to 1927 and graduated with a B.A. degree in Mathematics. During this period he was an outstanding student and was selected by the Institute as its candidate for the Rhodes Scholarship. He was a member of the track team as a high and broad jumper and a hurdler and was captain of the team in his senior year. He was also on the football squad and was a halfback on the team of 1926. Following his graduation in 1927 he returned to Rice Institute on a teaching fellowship and in 1929 was awarded the M.A. degree in mathematics.

Following his graduation he worked on a refraction seismograph crew for the Texas Company and in 1933 joined the Seismograph Department of the Sun Oil

Company in Beaumont as a Computer. From 1933 to 1947 he was active in all types of seismograph work and advanced to the position of Research Interpreter. In 1947 he was advanced to the position of Section Head in the Seismograph Department and was stationed in Dallas where he remained until his death.

Mr. Smiley was a member of, and was extremely interested in, the affairs of the Society of Exploration Geophysicists and for two years, 1947–1948, was secretary of the Southern Seismic Well Shooting Association. During his tenure of office the association made great progress. He was active in the Dallas Geophysical Society and a member of the American Geophysical Union. His church membership was in the Highland Park Presbyterian Church in Dallas.

Bill had many interests outside of his work. He was an avid reader, particularly of classical literature and his conversation was frequently interspersed with references to characters in mythology. He could quote many poems from memory and frequently did. He was a chess player of note, an excellent tennis player, and an expert bowler.

Bill is survived by his wife, Anne Hargrove Smiley, two sons, William Gilmore Smiley, III, aged 5 years and Robert Hargrove Smiley, 3 years, and by his mother, Mrs. William Gilmore Smiley of Houston.

Bill Smiley had a tremendous zest for life and probably packed into his 44 years more living and friendships than others who live to the traditional three score and ten. He had a wide circle of friends for whom he always had a glad word. In his passing, the geophysical fraternity, his friends, and his family suffered a grievious loss.

W. E. HOLLINGSWORTH

Beaumont, Texas
January 12, 1951

MEMORIAL

GEORGE WATSON CARR (1899–1950)

George Watson Carr, 51, president and owner of the Carr Geophysical Company, died in Houston, Texas, after a heart attack on the night of December 23, 1950. The shock of his death was augmented by the fact that it was completely unexpected; to the last, he was an energetic and hard-working man.

George's passing was a great blow to friends in virtually every walk of life, as well as a serious loss to the geophysical industry. His widespread interests—cattle, hunting, fishing, bird dogs and his work—made George many acquaintances. His warm personality, strong loyalty, forthright honesty and sense of fair play made these acquaintances into friends. His professional ability was widely recognized, and it was matched by his deserved reputation for complete integrity.

George Carr was born in Roanoke County, Virginia, on October 3, 1899, and spent his childhood in Virginia, Montana and Washington. His high school education was interrupted by World War I service in the U. S. Marine Corps; upon discharge he attained his high school diploma. After two academic years at the University of Washington, interrupted by periods of work that included nearly a year with the U. S. Coast and Geodetic Survey in Alaska, George transferred to the Colorado School of Mines. He spent three years there and was awarded the degree of Engineer of Mines in 1925.

Shortly after his graduation from college, George Carr was employed by the

Roxana Petroleum Corporation. His first assignment was to a torsion balance crew stationed on the Texas Gulf Coast. He gained experience in all phases of seismic and gravity exploration work while employed by the Roxana and its successor, the Shell Oil Company. He had risen to the position of supervisor before he resigned from the Shell in 1937 to join the General Geophysical Company. George left the General in 1944 to organize his own company.

George was married to Dorothea Wood Pickering in Victoria, Texas, on September 10, 1932.

He is survived by his widow, a resident of Houston; his mother, Mrs. W. W. Carr of Ojai, California; two sisters, Mrs. Alice Carr de Creeft also of Ojai and Miss Eva Carr of Santa Barbara, California; and a brother, Dugald M. Carr of Milford, Ohio.

George was a member of the Society of Exploration Geophysicists, the American Association of Petroleum Geologists, the Houston Geological Society, Sigma Alpha Epsilon social fraternity, Theta Tau honorary engineering fraternity, the Texas and Southwestern Cattle Raisers Association, and the Gulf Coast Field Trial Association.

George Carr always will be remembered by those who came in contact with him: an efficient and reliable business associate; a fair and understanding employer; a warm-hearted and loyal friend; an enthusiastic and pleasant hunting companion.

W. H. NEWTON

Houston, Texas
January 23, 1951

MEMORIAL

JOHN FRANCIS GALLIE (1913–1951)

John Francis Gallie III was born on August 13, 1913 at Tampa, Florida, the only child of John Francis and Grace Dornfeld Gallie. He died at St. Vincent's Hospital in New York City on January 12, 1951, as a result of injuries received from a fall.

Gallie attended the public schools at Houston, Texas. Following his graduation from the Sam Houston High School, he went to work for the Independent Exploration Company in 1935 where he first became interested in geophysics as a trainee. In 1937 Gallie became a computer for Subterrex. While working for this firm he realized the need of furthering his formal education, and was enabled to attend the University of Chicago through the encouragement of Dr. E. E. Rosaire.

After a term at Chicago, Gallie transferred to the University of Texas at Austin, Texas. In 1941 he won first prize in the South Texas Geological Society's

student paper award. He graduated from the University with honors in geology, receiving the degree of Bachelor of Science.

In 1941 Gallie joined the Humble Oil and Refining Company at Houston as evaluation geologist. During the war years 1942–1944 he was in the Federal Service at Washington, D. C., first with the Naval Ordnance Laboratory and subsequently the Petroleum Administration for War.

In the latter part of 1944 he moved to El Dorado, Arkansas, where he became senior geologist for the Arkansas Oil and Gas Commission and simultaneously partner in the firm of Crowell and Gallie, doing consulting work. He joined the Cabot Carbon Company at Pampa, Texas, as division geologist in 1945.

Gallie joined the staff of Ralph E. Davis, Petroleum Consultant, as evaluation geologist in 1949. He was senior geologist in the Houston office of the firm at the time of his death.

Gallie wrote numerous articles published in scientific and trade journals. He assisted in editorial duties connected with the publication of *Geophysics* while business manager of the Society of Exploration Geophysicists, a position he held from 1937 to 1945. A list of his publications would reflect a widespread interest and knowledge in the geological, geophysical, and engineering problems of the oil industry.

Gallie joined the Society of Exploration Geophysicists in 1936, the American Association of Petroleum Geologists in 1941, the American Institute of Mining and Metallurgical Engineers in 1945, and was a fellow of the American Association for the Advancement of Science.

In 1937 he married June Kerns. He is survived by his widow and two children, John Francis IV, born in 1942, and Christopher Thomas, born in 1947, who live in Houston.

John Gallie had a keen analytical mind and his interests were diverse. He was particularly fond of good music and enjoyed collecting symphonic recordings. Playing tennis was his favorite outdoor sport and recreation. He had a serious attitude toward life, but at the same time a whimsical sense of humor. John was a warmhearted and generous friend, and devoted to his family. His loss will be keenly felt by his friends and associates.

FELIX A. VOGEL, JR.

Houston, Texas
February 1, 1951

SOCIETY ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The Executive Committee has approved for publication the names of the following candidates for membership in the society. This publication does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it to the president within thirty days. Names of the references appear in parentheses after the name of each nominee.

ACTIVE

William Gideon Allen (C. C. Zimmerman, H. W. McDonnold, S. K. Van Steenbergh)
John James Bailey (J. A. Sharpe, L. G. Cornish, Bill Rollins)
Vale Kenneth Benson (R. L. Lay, A. A. Hunzicker, H. W. McDonnold)
Samuel Edward Bills (B. E. Richert, H. W. Rose, W. E. Hollingsworth)
Edwin George Cole (K. J. Warren, J. F. Johnson, S. K. Van Steenbergh)
Drexler Dana (H. Salvatori, T. P. Ellsworth, Robert Dyk)
Charles Edwin Ebert (Hart Brown, W. H. Fenwick, H. M. Zenor)
Elmer Joseph Faust (W. W. Hawthorne, C. H. Hightower, O. C. Clifford, Jr.)
George Floyd Francis (E. G. Schempf, L. K. Morris, Arne Junger)
Clarence Wilfred Hoffer (E. DeGolyer, M. G. Hoffman, R. H. Andrews)
Ray C. Lewis (R. F. Bennett, Paul Weaver, Al Nance)
Lincon Allen Martin (W. H. Denning, E. A. Pielemeier, R. A. Peterson)
William Harold McKelvy (F. F. Reynolds, J. D. Marr, H. V. Crowder)
Luis German Morales (P. M. Tucker, D. C. Skeels, W. K. Link)
Lindonor Mota (L. K. Morris, C. E. Riddell, P. J. Rusch)
Thomas Drury Nickerson (L. M. Hubby, B. D. Lee, L. G. Cowles)
Samuel Oliver Patterson (E. G. Schempf, K. A. Robertson, R. A. Peterson)
Walter Fred Pfennig (W. T. Lea, R. M. Bradley, R. W. Butler)
Richard Alba Pohly (G. H. Westby, H. M. Thralls, F. Goldstone)
Robert William Saubert (R. B. Baum, C. E. McClure, S. W. Fruehling)
John Lewis Scott (S. I. Hammer, R. D. Wyckoff, L. J. Peters)
Ellis H. Shannon (R. L. Lay, A. A. Hunzicker, B. H. Treybig, Jr.)
G. N. Smith (R. C. Coffin, Sidon Harris, Frank Kittredge)
Luigi Solaini (H. Salvatori, M. Boccalery, A. Belluigi)
George Herbert Vernon (R. L. Lay, C. R. Wallace, V. E. Briard)
James Lucius Wallace (A. L. Ladner, W. C. Kimball, M. E. Hibbler)
Bertram Wolfram, Jr. (F. F. Reynolds, J. D. Marr, R. R. Rosenkrans)

TRANSFER TO ACTIVE

Pertev I. Bediz (Opie Dimmick, B. F. Rummerfield, J. K. Ziegler)
Burl J. Boring (H. R. Prescott, L. E. Whitehead, B. G. Swan)
Herbert Henry Campbell (H. M. Thralls, G. A. Berg, Sidney Schafer)
John Lorraine Care (L. B. Trombla, R. H. Glover, J. A. Ballard)
David Allen Davis (E. A. Eckhardt, L. J. Peters, H. L. Rasé)
Hugh Patrick Downey (C. T. MacAllister, John Byers, R. L. Palmer)
Erle William Gilbert (no references given)
Daniel Edward Herlihy (W. B. Roper, H. E. Granberry, Evan Watts)
George Esmond Higgins (H. G. Kugler, H. H. Suter, V. C. Illing)
Peter Jacobsen, Jr. (W. C. Merritt, W. E. Franks, D. C. Skeels)
Gerrit Kok (G. W. Postma, J. J. Augusteijn, F. A. Van Melle)

Harold Morton Mooney (B. Gutenberg, C. H. Dix, G. Potapenko)
Archibald John Nicol (O. Dimmick, J. K. Ziegler, C. H. Green)
William Paul Ogilvie (P. P. Gaby, A. W. Farmilo, C. M. Moore, Jr.)
Lawrence Norman Ott (R. E. Davis, H. B. Morris, P. H. Garrison)
Otto Arthur Poirier, Jr. (N. J. Smith, Booth Strange, E. D. Gaby)
Will Silva (L. A. Scholl, Jr., O. A. Itria, R. L. Lay)
Samuel Aaron Spencer (A. J. Hintze, W. H. Courtier, R. P. Clark)
Robert M. Tesar (R. W. Gemmer, P. L. Lyons, G. E. Wagoner)
DeWitt Clinton Van Siclen (M. G. Cheney, R. A. Geyer, G. P. Woollard)
Floyd Eugene Wiancko (H. Hoover, Jr., John Sloat, E. G. Schempf)
John Lamar Worzel (R. A. Geyer, Maurice Ewing, G. P. Woollard)

ASSOCIATE

George Franklin Berry (L. F. Athy, H. R. Prescott, B. G. Swan)
Elmer Alexander Blomerth, Jr. (W. B. Brinnon, C. G. Dahm, W. M. Tottenham)
Fred Hudson Christian, Jr. (P. C. Cook, C. C. Zimmerman, H. W. McDonnold)
Earl Franklin Cunnyngham (L. B. Trombla, Charles Wallace, R. H. Glover)
William Walden Deaver (Sidon Harris, A. E. McKay, R. H. Dana)
Andre Pierre Delflache (G. E. Wagoner, R. J. Russell, V. Howe)
Billie Phil Edmiston (A. E. McKay, R. H. Dana, R. E. Davis)
Richard Quentin Foote (A. E. McKay, Sidon Harris, R. E. Davis)
John Frank Fuller (J. C. Karcher, F. J. Agnich, W. P. Harvey)
Ward Reese Gregg (Ray H. Wright, F. J. Agnich, C. H. Green)
Frederic Carroll Hall (P. R. Love, G. M. McGuckin, Wheaton Clark)
Francis Lawrence Hickey (H. J. Kidder, D. V. Bigelow, L. Castelli)
Wynand Hoogenhout (Oscar Weiss, B. Lombaard, M. Mawby)
Arthur Roy Johnson (R. O. Dunbar, John C. Stricker, Earle B. Blanton)
Richard Hyman Matthews (K. E. Burg, Fred Agnich, Earl Thomas)
Bascom Loran Mitchell (J. F. Johnson, K. J. Warren, S. K. Van Steenbergh)
Stuart Creighton Mut (L. P. Whorton, H. F. Dunlap, J. P. Woods)
Frederick D. Nichol (Sidon Harris, A. E. McKay, William Schriever)
William Ross O'Brien (Jack Kern, R. K. Carter, W. A. McFadden)
Lloyd Audell Randow (L. J. Peters, W. C. Lamb, D. E. Cook)
Richard Ralph Ross, Jr. (Hobart Stocking, R. B. Ross, M. A. Tibbetts)
Carl Robert Rowley (F. F. Reynolds, F. R. Coryn, Hugh Porter, Jr.)
Leo Joseph Schaefer, Jr. (Sidon Harris, A. E. McKay, Elmer Blake)
William Lloyd Denzil Smith (L. Castelli, H. J. Kidder, D. V. Bigelow)
Edward Robert Thirkhill (J. M. Nash, J. B. Macelwane, F. Goldstone)
Ami Hugh Trask (M. C. Kelsey, E. F. McMullin, F. Rollins)
George Glenn Vanderdoes (F. F. Reynolds, J. D. Marr, R. R. Rosenkrans)
Henry Allen Wakefield (C. K. Jordan, F. L. Searcy, Roland Hughes)
Jim Roy Williams (Sidon Harris, A. E. McKay, R. H. Dana)
Max Frederick Williamson (R. M. Bradley, W. E. Allen, E. W. Johnson)
Dwayne Russell Witherspoon (R. L. Lay, A. A. Hunzicker, J. S. Welboan, Jr.)
D. O. Wyble (L. O. Bacon, W. A. Longacre, B. H. Boyum)

TRANSFER TO ASSOCIATE

Edward Irving Barton (William C. Lamb, John Robinson, Phillip Cerveny)
William Davison Black (C. H. Green, E. J. Stulken, C. M. Moore, Jr.)
Wayne Forrest Bohanan (M. D. Wickerham, R. C. Holmer, H. E. Stommel)
Foster Ernest Endacott, Jr. (J. R. Gilliland, Jack Martin, H. E. Stommel)

Robert Bridger Hill (R. W. Carter, G. C. Howard, Florence Robertson)
Donald Whitney Jones (B. F. Howell, Jr., C. E. Williams, J. D. Moredock)
Ralph Harrison Jones (Chester Sappington, M. R. Henderson, J. C. Hollister)
Rulon Stuart Mahannah (F. Goldstone, R. C. Kendall, R. F. Christy)
Homer Neil Opland (D. F. Warner, H. E. Stommel, C. A. Heiland)
John Renowden Reese (J. W. Northrop, J. A. Harris, C. H. Dix
Michael Stephen Reford (J. H. Hodgson, A. H. Miller, J. T. Wilson)
Robert James Searls (A. A. Brant, C. A. Heiland, R. C. Holmer)
Robert Burns Shaller (C. H. Green, C. M. Moore, Jr., J. H. Wilson)
Robert Edward Sheriff (L. P. Geldart, F. A. Hale, J. R. Leggett)

ADDITIONAL APPLICATIONS APPROVED FOR PUBLICATION

ACTIVE

Samuel Judson Allen (J. R. Woolson, W. H. Myers, R. A. Peterson)
John Malcolm Baird (J. W. Bolinger, A. G. Starr, S. A. Teasley)
Charles Thomas Burchett, Jr. (R. W. Gemmer, H. W. Brown, G. E. Wagoner)
Ellsworth Mathews Curry (H. R. Thornburgh, K. S. Cohick, J. C. Waterman)
Woodson H. Dawson (R. W. Gemmer, H. W. Brown, G. E. Wagoner)
Charles Edward Day (James C. Harper, J. E. Owen, W. T. Born)
William James Fennessy (R. S. Duty, Jr., L. B. Rogers, W. B. Duty)
Richard Holmes Hopkins (W. E. Hollingsworth, J. E. McGee, L. L. Nettleton)
Walker H. Josselyn (R. W. Gemmer, H. W. Brown, P. L. Lyons)
Walter Eli Martin (H. W. Brown, R. W. Gemmer, P. L. Lyons)
Thomas Francis Miller (L. G. Ellis, J. H. Sawyer, W. E. Hollingsworth)
C. B. Smith, Jr. (E. L. Mount, B. G. Swan, L. F. Athy)
Charles Brunson Vogel (N. D. Smith, O. B. Manes, A. J. Hermont)

TRANSFER TO ACTIVE

Harold Lloyd Gaither (F. F. Reynolds, J. D. Marr, G. A. Grimm)
Cleveland Fane Moore, Jr. (R. F. Bennett, C. B. Smith, R. D. Roberts)

ASSOCIATE

Nigel Allister Anstey (E. J. P. van der Linden, J. E. Hawkins, R. S. Finn)
Cecil Edward Dalik (H. J. Kidder, D. V. Bigelow, L. Castelli)
William Robert Drake (R. W. Gemmer, H. W. Brown, J. T. Wilson)
Charles Richard Glanville (H. F. Dunlap, J. L. Martin, L. P. Whorton)
Robert Emmet Murphy, Jr. (P. R. Love, G. M. McGuckin, W. C. Clark)
James Sewall Peterson (A. E. Storm, Sam Zimerman, S. R. Spivey)
Merrill Smith (R. L. Lay, C. R. Wallace, A. A. Hunzicker)
John Nelson Stoddard (P. S. Swenson, S. C. Stoneham, J. A. Smith)
J. R. Zweers (E. L. Mount, B. G. Swan, L. F. Athy)

TRANSFER TO ASSOCIATE

Charles Robert Holmes (J. B. Macelwane, V. J. Blum, Florence Robertson)
Leonard V. Lombardi (T. C. Poulter, L. M. Swift, W. M. Wells)
Cecil Carter Miller (J. B. Macelwane, V. J. Blum, W. J. Harkey)
John Petrocco (R. F. Bennett, R. D. Roberts, F. A. Smith)
David J. Stuart (no references given)

REPORT OF STANDING COMMITTEE ON RADIO FACILITIES

Membership: R. D. Wyckoff, Chairman
W. M. Rust, Jr., V. Chairman
Daniel Silverman

In accordance with the original organization plan, the roster of this API Subcommittee comprises members of a Standing Committee of the Society of Exploration Geophysicists known as the Radio Facilities Committee. Accordingly, any actions of this subcommittee reflect the opinions or desires of the SEG Membership at large, and, hence are representative of the geophysical users of radio within the entire petroleum industry in spite of the fact that the majority of this group may not be affiliated directly with the API. We trust that the Central Committee will continue with this plan of organization for this Subcommittee.

The major item before this Subcommittee during the past year involved the Federal Communications Commission General Radiolocation Hearing, Docket 9233. A suitable joint statement by the API and SEG Committees was prepared in time to meet the scheduled date in April. Subsequently, this Hearing was indefinitely postponed by the FCC, and we have no intimation regarding the probable future action. However, the preparations already made require no revision, so we stand prepared for any future action.

With the assistance of our representative, Mr. J. E. Keller, certain minor details regarding licensing procedure in the geophysical group have been cleared with the FCC. These are matters raised by SEG Members and first cleared with the Petroleum Radio Frequency Coordinating Association's Executive Committee.

(1) In the 1600–1700 kc channels, 100 watts maximum input will be allowed on *special* showing of need instead of the usual 10-watt limitation. This is particularly required for aircraft-to-ground coordination and marine exploration.

(2) Geophysical operators using the petroleum service frequencies agreed upon by the NPRFCA need submit their license applications for approval only to the Regional Chairman whose jurisdiction covers the home office of the operator. The FCC will recognize such approval as applying to the entire U. S.—except for a band 75 miles wide adjoining the Canadian border and over its entire length.

(3) The Commission would not accept a proposal to omit the northern borders of Montana and North Dakota from the above exception. Thus operation within the above boundary territory on any frequency above 30 megacycles will require special approval and a specific frequency assignment by the FCC.

While we have met with no serious problems during the past year, and geophysical users of radio are, in general, satisfied with the present situation, attention must be called to the very tentative status of certain existing frequency allocations. At least two major problems must confront us at such time as the FCC is prepared to bring them up for final consideration.

(1) The five channels within the 1600–1700 kc band which have been the mainstay of geophysical operations for the past twenty years lie within a band involving international agreements. Until certain Inter-American discussions are complete, our status in these important channels remains temporary. We have every assurance that our needs will be adequately presented at these discussions, but complete jurisdiction is not in FCC hands. If these channels are lost to geophysical use, replacements must be found in the same region of the spectrum.

(2) Radiolocation methods have become a necessity in modern exploration. At present, microwave Shoran and Radar Channels are available on an experimental basis. Medium-frequency bands for phase-comparison methods have also been made available on a similar basis after special representations and hearings by the operators involved.

Radiolocation methods must be given the status of a recognized Service before the

situation can be considered satisfactory. When the pending FCC Hearing on Docket 9233 has been completed, some such action may result. We anticipate probable recognition in the case of the microwave frequencies for the line-of-sight Shoran or Radar methods. However, lack of channels may seriously jeopardize the situation in the very important medium-frequency bands required for the long-range phase-comparison methods. These comprise the only hope for a non-line-of-sight service suitable for distances much beyond about twenty miles.

This Subcommittee wishes especially to express their sincere appreciation of the very great assistance given to them and their associates in the geophysical industry by Mr. Joseph E. Keller.

R. D. WYCKOFF

Pittsburgh, Pa.
November 10, 1950

JOINT REGIONAL EXPLORATION MEETING
TEXAS HOTEL, FORT WORTH, TEXAS
NOVEMBER 30 AND DECEMBER 1, 1950

The Joint Regional Exploration Meeting, held in Fort Worth on November 30 and December 1, 1950, was sponsored by the Fort Worth Geophysical Society, the Fort Worth Geological Society, the Dallas Geophysical Society, the Tulsa Geophysical Society, the Ark-La-Tex Geophysical Society and the Permian Basin Geophysical Society.

The general theme on the technical program was the discussion of the geology and geophysics of several sedimentary basins of the Southwest. Companion geological and geophysical papers were presented on the Delaware Basin, the Anadarko Basin, southeastern New Mexico, the Plainview Basin, the Ark-La-Tex Area and the Marfa Basin. Mr. Ira H. Cram, in the opening address, stressed the importance of constructive imagination on the part of geologists and geophysicists in the successful exploration of difficult areas such as these.

The final afternoon of the technical program was devoted to geophysical papers concerning dip logging and seismic velocity problems. On Friday afternoon from 5:00 to 6:00 P.M., a cocktail party, through the courtesy of certain seismic and service companies, was held. This party was open to all registrants and the attendance was around 600. Friday evening a breakfast dance was held in the Crystal Ballroom in the Texas Hotel from 9:00 to 1:00 P.M. The dance attendance was 410 people.

The following is an analysis of the registered attendance of this regional meeting:

SEG members in attendance		479
AAPG members in attendance		551
Members of both AAPG & SEG (overlap)		(180)
Members of SEG & AAPG in attendance		850
Non-Members:		
Ladies	6	
Students	17	
Geophysical suppliers	17	
Editors of trade journals	7	
Representatives of geophysical contractors and producing companies who did not state their affiliation	78	125
TOTAL REGISTERED ATTENDANCE		975

JAMES F. JOHNSON

Fort Worth, Texas
January 25, 1951

THIRD WORLD PETROLEUM CONGRESS

In order to ensure continuity in the organization of World Petroleum Congresses, it was decided, at the time of the First World Petroleum Congress (London, 1933), to set up a Permanent Council for the organization of these congresses. Under the auspices of this Council the Second World Congress took place in Paris in 1937, and the Third Congress is to be held in The Hague/Scheveningen (Holland), as already announced, from May 28 to June 6, 1951. The initiative for holding the coming Congress in the Netherlands was again taken by the Permanent Council.

The Permanent Council of the World Petroleum Congress is composed of representatives from a number of the leading countries concerned in the production and processing of petroleum. These representatives are appointed by the official Institutes or equivalent organizations for petroleum affairs in the countries concerned.

The death in September 1950 of the last Chairman of the Permanent Council of the World Petroleum Congress, Colonel Louis Pineau of France, necessitated the election of a new Chairman.

The newly-elected Chairman is Mr. G. A. Tuyl Schuitemaker of the Netherlands, Chairman of the Petroleum Engineering Section of the Royal Netherlands Institution of Engineers and Adviser to the Royal Dutch/Shell Group.

The Permanent Council of the World Petroleum Congress is now composed of the following members: Mr. G. A. Tuyl Schuitemaker, the Netherlands, President; Mr. F. S. Clulow, Dr. G. Egloff, Dr. K. G. Mackenzie and Dr. E. V. Murphree for the United States; Colonel S. J. M. Auld, Mr. T. Dewhurst and Mr. H. C. Tett for Great Britain; Mr. J. Filhol, Mr. X. Normand and Mr. S. Scheer for France; Mr. J. A. Beukers and Dr. J. N. J. Perquin for the Netherlands; Prof. P. Erculisse for Belgium; Dr. Carlos Perez de la Cova for Venezuela; and Dr. R. K. Stratford for Canada. Representatives for Austria and Italy are still to be appointed.

A proposal for the organization of a Western European Section of the Society of Exploration Geophysicists will be made during the Third Congress by Dr. A. Van Weelden, The Hague.

AMERICAN GEOLOGICAL INSTITUTE

The Board of Directors of the American Geological Institute held its semi-annual meeting in St. Louis on February 18. In addition to routine business, it was announced that the Association of American State Geologists had become a member of the Institute. Appointments from the Association to the Institute's Board are: Wilson Laird, 1951; E. P. Rothrock, 1951–1952.

The Board also confirmed J. V. Howell, consulting geologist of Tulsa, Oklahoma, as chairman of the Publications Committee, and G. O. Raasch of the Illinois State Geological Survey as chairman of the Committee on Public Relations. The 1951 annual meeting of the Board will be held in Detroit, Michigan, in November.

ENROLLMENT OF GEOLOGISTS AND GEOPHYSICISTS IN NATIONAL SCIENTIFIC REGISTER

Planning for the mobilization and effective use of the scientists and engineers of the United States for purposes of national defense is now under way. Appointment of a committee composed of leaders in science and industry by the National Security Resources Board is a recent step. The representative of the geological professions on this committee is E. De Golyer; the chairman is Charles A. Thomas, vice-president of Monsanto Chemical Co. and former president of the American Chemical Society.

A basic element in the entire program for maximum use of the nation's scientific manpower will be an adequate scientific register. This will tell us the magnitude and nature of the national pool of technological competence.

In order to secure this information, the N.S.R.B. was instrumental last summer in causing the establishment of a National Scientific Register Office in the U. S. Office of Education. This office has let contracts with the American Chemical Society, the National Research Council and the American

Institute of Physics for enrollment of all physical and biological scientists and mathematicians. Enrollment will be accomplished through the societies and the register will also be kept up to date through the societies. The American Geological Institute has been asked to ensure the enrollment of all geologists and geophysicists.

The project must start essentially from scratch because the records of the World War II National Roster are completely out of date. Also, with the tremendous increase in the number of working scientists since 1945, its records are very incomplete.

Some geologists and geophysicists who are included in American men of Science, filled out a comprehensive registration form in 1948. These men *will not* be asked to answer all the questions on the new simpler form, but will be asked to fill out basic questions in the interest of uniformity.

The following methodology is being established for this project to ensure effective coverage. It is hoped that use of this method will spread the work, prevent wasteful and annoying duplication, and get the job done more promptly and effectively.

1. The register will include all geologists and geophysicists with a bachelors degree (or equivalent) and all graduate students.
2. Circularization will be accomplished by district committees. These will center in active local societies, state geological surveys and major departments.
3. Each committee will be responsible for full circularization in its district, and has been asked to estimate the number of forms required for this purpose.
4. Franked envelopes requiring no postage, will be utilized. Where possible, these will be preaddressed.
5. Each form will be accompanied by a careful instruction memorandum.
6. A card file will be maintained in AGI headquarters showing which forms have been completed and certain other pertinent data. The register will be used for the following purposes:
   (a) by Scientific Advisory Committees in the Selective Service System. It is expected that these committees will review appeals for deferment which are made to The President and that the information on file with the Register will be used in the consideration of such cases.
   (b) by the National Security Resources Board. This agency is charged with responsibility for the planning of general mobilization, both military and civilian, and will use the information in determining the requirements for scientific manpower in various activities.
   (c) by the National Research Council and by the American Geological Institute in determining the distribution and availability of earth scientists among the various specialized occupations.
   (d) as a means whereby Government agencies may identify personnel with specialized training or experience for unusual work requirements.
   (e) in the preparation of studies and recommendations to Government agencies, such as the National Security Resources Board, concerning the needs for geological scientists in civilian occupations.

In addition, it will furnish information concerning the composition and structure of the geological professions which will be invaluable.

The full cooperation of every member of the geological professions is earnestly requested so that our part in this national effort may be performed quickly and effectively.

DAVID M. DELO

REPORT ON THE AMERICAN GEOLOGICAL INSTITUTE MEETING OF FEBRUARY 18, 1951

A meeting of the Board of Directors of the American Geological Institute was held in St. Louis on February 18 at the time of the meeting of the A.I.M.M.E. Nine of the eleven member organi-

zations were represented by one or both of their directors. Unfortunately, neither of the directors representing S.E.G. was able to be present. Father Macelwane was asked to represent the society informally. The current activities of the Institute include several which should be of interest to our members.

The Geological Information Committee, under F. W. Rolshausen, is working on a project to prepare geologic strip maps of main highways. The first such map to be undertaken is on Highway 75 from Galveston to the Red River. This would include geology and geological exposures, structural, physiographic and topographic features, oil fields, salt domes, soils and vegetation as related to formations and information on industry, agriculture, historical and other points of interest. The Houston Geological Society is starting work from Galveston northward.

The directors have approved, in principle, a project for the preparation of a Glossary of Geological Terminology. Two such works have been published but neither is considered satisfactory for modern use.

As was mentioned in our note on the A.G.I. in the January number (p. 181) publicity for geology and geologists (including geophysicists) was the original germ, largely fertilized by Carey Croneis, from which the Institute has grown. The Institute has now issued a little booklet on "Suggestions for a Program of Public Education" which points out methods and public groups which can be used to advance public appreciation of the profession. Copies are available from Institute headquarters to interested committees or individuals.

There has been some misunderstanding among our members about the manner of designation of the A.G.I. directors representing S.E.G. This has come about in part because our regular meeting is in March or April and the Annual Meeting of the A.G.I., at which directors' terms begin or end, is in November. Also, the S.E.G. has decided that the prior past president will automatically become a director. To get this system started, L. L. Nettleton has been named to a second term. The past directors and immediately future ones, according to this system, are as follows:

S.E.G. Annual Meeting			*Directors at time of A.G.I. Annual Meeting*	
	Current	*Appointed*		
Mar. 1948 Chicago	E. A. Eckhardt	L. L. Nettleton		
			Nov. 1948 Washington	Eckhardt Nettleton
Mar. 1949 St. Louis	L. L. Nettleton	H. C. Cortes		
			Nov. 1949 El Paso	Nettleton Cortes
Mar. 1950 Chicago	H. C. Cortes	L. L. Nettleton		
			Nov. 1950 Washington	Nettleton Cortes
Mar. 1951 St. Louis	L. L. Nettleton	A. Gilmour		
			Nov. 1951 Detroit	Nettleton Gilmour
Mar. 1952	A. Gilmour	G. E. Wagoner		
			Nov. 1952	Gilmour Wagoner

L. L. NETTLETON

THE NEW MAGNETIC OBSERVATORY OF THE UNIVERSITY OF HOUSTON

The new Magnetic Observatory of the University of Houston, which is the third such observatory in the United States, is now in operation. All final adjustments and temperature compensation checks have now been completed and the timing device for the records has been installed.

Up to now there were only two magnetic observatories in the United States, one at Cheltenham near Washington, D. C., and the other at Tucson, Arizona. The Ruska Instrument Corporation offered to build and donate the instruments and Captain Roberts promised full support on the part of the U. S. Coast and Geodetic Survey to establish this observatory in Houston. The University of Houston agreed to furnish the site and buildings and to operate the station under the auspices of the U. S. Coast and Geodetic Survey.

Two small buildings have been erected on the University of Houston campus, one for making periodic observations to determine the strength and direction of the earth's magnetic field and the other to house delicate recording instruments which continuously record these changes of strength and direction. These buildings are of unusual construction. They are wooden buildings with concrete piers for the erection of the instruments and are entirely non-magnetic. Copper nails have been used and the locks, hinges and other hardware are of solid brass. All materials were checked with delicate instruments to be certain they did not contain any iron impurities. The ground over a considerable area around the building was checked for buried iron pipes and iron trash and wherever iron was found, it was removed. A water line near the building was relocated to be at a safe distance.

The information obtained at this observatory will be of great value to the U. S. Coast and Geodetic Survey in their magnetic control work in the United States. The information will also be available to the oil and mining industry for their geophysical work and to the communications services.

The recording instruments installed at the University of Houston are of the same type as those made by the Ruska Instrument Corporation for the new magnetic observatories in Alaska, Honolulu, Philippine Islands and Argentina. The company is at this time producing four additional observatory installations for Europe. Persons interested in obtaining copies of the records or information concerning magnetic disturbances should contact Dr. R. W. Long of the University of Houston.

MANPOWER POLICIES MAY PERIL MINERAL PRODUCTION

The loss of trained geologists and geophysicists to the Armed Services will imperil our ability to prepare and maintain an adequate national defense, according to the American Geological Institute.

The Institute's Board of Directors called upon mobilization planners and educational agencies to maintain an increasing number of geologists and geophysicists at work to locate the enlarging amounts of strategic mineral supplies needed for civilian and military purposes. It pointed out that the search for mineral supplies is done blindly and ineffectively unless under the guidance of trained and expert scientists. "For most of the critical minerals," it stated, "the present supply of geologists and geophysicists is no more than adequate to sustain discoveries at present rates."

Concern was also voiced that the education of students to increase the number of trained geological scientists would be decreased so materially that it will weaken the nation's ability to meet an all-out emergency in the future.

The American Geological Institute is composed of twelve national geological and geophysical societies which represent the approximately 17,000 individuals in these professions in the United States. The great majority of them are engaged in scientific exploration for oil and gas, metals and other strategic and critical earth materials. The text of the resolution, unanimously approved by the Board of Directors, follows.

"*RESOLVED* that:

"1. The United States can neither sustain an expanding defense economy nor meet a war emergency without accelerating the rate of discovery of essential minerals such as oil, gas, metals and strategic materials. Unless the discovery rate increases to exceed the increase in depletion rate, the supply of these critical minerals will become inadequate for defense preparation and still less adequate for war.

"2. The discovery rate of these critical minerals can not be accelerated without an increasing supply of geologists and geophysicists. Minerals are found through the application of geology and geophysics to the search. Capital is required, and equipment and mechanical skill, but the search is blind without geology and geophysics.

"3. For most of these critical minerals the present supply of geologists and geophysicists is no more than adequate to sustain discoveries at present rates.

"4. The loss of geologists and geophysicists from the search for minerals to the Armed Services

will slow down the rate of mineral discoveries and imperil the nation's ability to prepare adequate defense or wage successful war.

"5. Failure to train additional geologists and geophysicists will lessen in increasing ratio the nation's capacity to strengthen its defense or to meet an emergency. While the emergency lasts, institutions of higher education should give geological and geophysical training to every qualified and able student who wants it and should maintain teaching staffs adequate therefore."

AMENDMENTS TO THE BYLAWS

A special committee on the constitution, appointed by President Wagoner, has reported its recommendations for amending the Bylaws of the society (*Geophysics*, January, 1951, p. 180). Action upon these amendments will be taken by the outgoing and incoming Councils April 24, 1951. In view of their possible amendment the Constitution and Bylaws, customarily published in the April issue, will appear in *Geophysics*, July, 1951, with a report of the Joint Council action.

PERSONAL ITEMS

JERZY SOSNOWSKI has become party chief for Beaver Geophysical Services, Calgary, Alta., Canada.

THOMAS L. ALLEN announces his affiliation with Portable Seismograph Inc. as president and general manager, with offices at 714 Frost National Bank Building, San Antonio, Texas.

PAUL F. CLEMENT, formerly District Representative for the Pacific Coast Section, S.E.G., has been transferred by his company, Gulf Research and Development Company, to Gillette, Wyoming. His mailing address is Box 204. JOHN D. HALE, Seaboard Oil Company, Haberfelde Building, Bakersfield, California, has been appointed by the Executive Committee of the Pacific Coast Section to fill out Mr. Clement's unexpired term.

L. O. SEAMAN, formerly in charge of the geophysical department of Sinclair Oil & Gas Co. at Tulsa, is now in that position at the Fort Worth office in the Fair Building.

EDMUND BORYS has joined El Capitan Oil Co., Box 310, Midland, Texas, as geologist. He was formerly with Hunt Oil Co., Dallas.

C. WIN PAYNE has resigned as president of the Permian Basin Geophysical Society. He recently joined the Texas producing division of Pure Oil Co. in Fort Worth. E. L. MOUNT, seismic supervisor for Continental Oil Company and 1st vice president of the Midland Section of S.E.G., will replace Mr. Payne as president.

WARREN H. SMITH, party chief for The Texas Co., has transferred from Corpus Christi to Denison, Texas.

JOHN H. WILSON, secretary-treasurer of the society, 1936–1937, has resigned as vice president of Independent Exploration Co. to open offices as a consultant, specializing in exploration programs, and will continue to serve his former company in that capacity. His address is Room 10, 740 West Fifth St., Fort Worth 2, Texas.

DAVID B. CAMPBELL has become district manager of the Independent Exploration Co. Fort Worth office. Assisted by GEORGE H. HARRINGTON, JR., he is located in the company's new offices at 740 West Fifth Street, Fort Worth.

ROBERT F. DUNDON was mentioned as having joined Aramco Overseas Co. in Rome, Italy in the last issue of *Geophysics*. Although Bob's address is in care of the Aramco offices in Rome, he is still definitely a member of the Geophysical Service Inc. organization.

WILLIS W. HARDY of Socony-Vacuum Oil Co., HENRY C. CORTES of Magnolia Petroleum Co.

(president of the society 1945–46), and W. G. GREEN, president of Well Surveys, Inc., have been elected directors of Well Surveys, Incorporated after the recent purchase by Lane-Wells Co. of 50% of the capital stock in that company. CHARLES H. DULLER is vice president and treasurer. The other members of the board are Rodney S. Durkee, president, and Russell M. Otis, manager of research and patent department of Lane-Wells Co.

NEAL CLAYTON, formerly with Republic Exploration Co., has joined the Century Geophysical Corp. as geophysical supervisor. He may be addressed in care of the company at 1333 North Utica, Tulsa 6, Oklahoma.

J. R. MORAN, a senior geophysics student at California Institute of Technology, has been called to active duty as a jet fighter pilot in the U. S. Air Force. He may be addressed: Lt. J. R. Moran, Fighter Flight, Air Task Group 3.4.1, APO 187, San Francisco, California. Lt. Moran intends to continue his education in geophysics after the current national emergency.

WILLIAM H. CHARTRES, ROBERT D. GRAVES, HUGH W. HARDY, DONALD N. MOONEY, J. R. MORAN, JAMES H. STELLOH, RAYMOND C. ZONGKER and ROY G. TRAFTON are among the members of the society now serving with the armed forces of the United States. All SEG members whose connection with the society has been severed by calls to active duty may place their membership on inactive status through notifying the business manager, giving him their permanent home addresses.

F. O. MORTLOCK, Gulf Oil Corp., has become division geophysical supervisor for the Fort Worth division of the company.

JOHN M. CRAWFORD, district representative to the society from the Tulsa Local Section, has become supervising research geophysicist and head of the new geophysical research division of Continental Oil Co. in Ponca City, Oklahoma. L. E. WHITEHEAD is now superintendent of the newly created operations division of Continental, embodying the gravity and seismic divisions as sections. FRANK SEARCY is superintendent, and R. F. HUGHES, assistant superintendent, of the equipment division, formerly called the research and development division of the geophysical department.

DONALD M. DAVIS, geologist with the Union Oil Company of California, was recently transferred to the company's newly organized northern division offices in Sacramento.

EDWARD L. DELOACH has been transferred to the Dallas office of the Atlantic Refining Co. as regional geophysicist. His new mailing address is Box 2819, Dallas 1, Texas.

HENRY SALVATORI, president of Western Geophysical Co. of America, has been elected chairman of the Wildcat Committee of the Western Oil and Gas Association, Los Angeles.

ARNOLD BARNES, sales engineer in the Tulsa office of Century Geophysical Corp., has been transferred to Dayton, Ohio, where he will serve Century as Mid-West representative. The territory served by Mr. Barnes includes Ohio, Illinois, Indiana, Tennessee and Kentucky.

GEOPHYSICAL RESEARCH DIRECTORATE of the Air Force Cambridge Research Laboratories, Cambridge, Mass., has announced the need for a physicist, a chemist and a meteorologist. Applications for the civil service examination are sought from scientists and technical supervisors of superior capacity who can conduct specialized investigation of fundamental problems related to the atmospheric sciences. The newly organized Geophysical Research Directorate offers the opportunity for freedom of action to scientists with training in the fields of physics, chemistry, or meteorology, who have ability to plan, administer and coordinate the activities of, or to perform research in fundamental problems related to the earth's atmosphere, including the troposphere, stratosphere, and ionosphere, and the prediction of elements thereof in time and space. Some types of research performed in the Geophysical Research Directorate are: Forecasting of atmospheric parameters in time and space by means of seismological techniques; Propagation of electromagnetic waves and compressional waves through the atmosphere, the lithosphere and the hydrosphere; electrical and acoustical phenomena in the atmosphere.

Apply to Board of U. S. Civil Service Examiners, Air Force Cambridge Research Laboratories, 230 Albany Street, Cambridge 39, Massachusetts.

GSI REORGANIZES. Reorganization of Geophysical Service Inc. of Dallas, Texas, into three companies has been announced by CECIL H. GREEN, newly elected president of the Dallas company. Effective in January, 1951, the two additional companies which began operations are General Instruments Inc., covering manufacturing operations, and Geophysical Service Incorporated, covering exploration activities in Latin America. Personnel changes involving members of the SEG follow.

EUGENE MCDERMOTT, former chairman of the board of Geophysical Service Inc., is now serving in that capacity with General Instruments Inc. H. B. PEACOCK, former president of Geophysical Service Inc., is now chairman of the board. J. E. JONSSON, former executive vice president and treasurer of Geophysical Service Inc., is still serving as treasurer of that organization in addition to his position as president and treasurer of General Instruments Inc. and treasurer of Geophysical Service Incorporated. CECIL H. GREEN, former executive vice president of Geophysical Service Inc., is now serving as president of that organization and as chairman of the board of Geophysical Service Incorporated. FRED J. AGNICH, formerly supervisor of Geophysical Service Inc., is now executive vice president in charge of operations for that organization. R. C. DUNLAP, JR., vice president, west coast representative and supervisor of Geophysical Service Inc., is transferring from the Bakersfield, California office to Dallas, Texas as vice president in charge of sales. K. E. BURG, consulting geophysicist with Geophysical Service Inc., is now vice president in charge of special problems and engineering. J. W. THOMAS, formerly vice president, Mexico representative and supervisor of Geophysical Service Inc., is now president of Geophysical Service Incorporated. His offices are at Edificio Eliseo, Ejido No. 9, Despacho No. 42, Mexico City. G. J. KOHLER, supervisor of Geophysical Service Inc. formerly at New Orleans, has been transferred to Mexico City as assistant secretary and supervisor of Geophysical Service Incorporated. NEIL W. MANN, former Brazil representative and supervisor of Geophysical Service Inc. at Belem, Para, has moved to Rio de Janeiro as manager of Brazil operations for Geophysical Service Incorporated. His offices are at Avenida 13 de Maio 13, Edificio Municipal Sala 1919. A. E. STORM, formerly party chief and supervisor in Arabia for Geophysical Service Inc., is now division manager of the Arabian operations of that organization, at Dhahran, Saudi Arabia. C. M. MOORE, JR., supervisor with Geophysical Service Inc., is now Manager of the Canadian division with offices at 510 Ninth Avenue West, Calgary, Alberta. FREDERICK ROMBERG is returning to Geophysical Service Inc. as division manager with offices in Houston, Texas. T. P. ELLSWORTH, formerly chief geophysicist with Richfield Oil Corporation, is joining Geophysical Service Inc. as West Coast division manager, with office at 109 George Hay Building, Bakersfield, California. W. J. OSTERHOUDT is moving from Houston, Texas to Durango, Colorado, where he will continue with Geophysical Service Inc. as consulting geophysicist. RAY H. WRIGHT, formerly supervisor in Canada for Geophysical Service Inc., has been transferred to Houston, Texas, as a supervisor in Gulf Coast operations. W. P. HARVEY has been promoted from party chief to supervisor of West Texas operations for Geophysical Service Inc., with address at 424 East Cedar Street, Midland. R. H. RAINEY has been appointed supervisor of Geophysical Service Inc. in the Canadian division office at Calgary, Alberta. R. D. EVERETT, formerly party chief with Geophysical Service Inc. on the West Coast, has been transferred to the Dallas office as field personnel director. JOHN F. IMLE is now associated with Geophysical Service Inc. in the capacity of field safety engineer. PAUL WALTON has been appointed party chief for West Texas operations, presently at Tahoka, Texas. LEWIS SOLE is again associated with Geophysical Service Inc. as party chief at Houma, Louisiana. J. O. CARROW is now party chief in Houma, Louisiana. HORTON SMITH, JR. has been promoted to party chief. JOHN E. GAEDE is party chief in Stettler, Alberta, Canada.

E. V. MCCOLLUM and CRAIG FERRIS have formed the GeoSeis, Inc., at Tulsa. They are now associated with E. V. McCollum & Co., which firm will be closely associated with the new company. Their service in the field of seismograph prospecting will cover the United States and Canada, and field crews are already working in some areas.

Both McCollum and Ferris have been active in association work for many years. Both are members of the Society of Exploration Geophysicists, American Geophysical Union and the American Physical Society. McCollum is a member of the Seismographical Society of America and in 1948–49 served as secretary-treasurer of the Society of Exploration Geophysicists.

SOCIETY OF EXPLORATION GEOPHYSICISTS

MEMBERSHIP LIST (FEBRUARY 1, 1951)

Members are urged to report to the Business Manager any inaccuracies in the following list, which was compiled from the most recent information at hand.

A

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Crenshaw, C. C.
Dunbar, R. O.
Elliott, S. D.
Ericson, Harry B.
Hintze, A. J.
Johnson, E. W.
Johnson, J. R.
Kidd, R. L.
McMillan, Fred L., Jr.
Mendenhall, H. L.
Piety, R. G.
Rice, Robert B.
Tilley, Aubra E.
Tucker, R. H.
Bethany
Drake, William R.
Blackwell
Beightol, R. O.
Clark, K. M., Jr.
Broken Arrow
Hawkins, J. E.
McCutchen, Edgar O.
Drumright
Moore, C. F., Jr.
Edmond
Jones, Leland W.
Enid
Braithwaite, Al
Caldwell, Walter T.
Clifton, R. L.
Hobart, Henry M.
Ft. Gibson
Graves, John M.
Ft. Sill
Jackson, Robert W.
Madill
Langstroth, Ward T.
Midwest City
Rudolph, Wm. E., Jr.
Muskogee
Voegeli, Richard A.
Norman
Fazekas, John E.
Johnson, Hamilton M.
Schriever, William
Thompson, Wilbur L., Jr.
Oklahoma City
Abbott, Wayne R.
Ballard, James A.
Cody, C. C.
Deupree, Edwin A.
Dunn, George V.
Fee, S. T.
Green, Thomas H.
Hadler, Harry G.
Herr, H. K.
Hewitt, Marvin R.
Hill, John R.
Kamitchis, J. E.
Kurk, Edwin H.
Lambert, G. D.
Perry, W. B.
Ratliff, D. W.
Roane, W. H.
Roberts, Francis A.
Seifert, Wesley H.
Smith, Mrs. Francis E.
Smith, C. B.
Stones, J. Eugene
Sype, William R.
Tesar, Robert M.
Thomsen, Erik
Trombla, Lynn B.
Wallace, Charles H.
Warren, P. R.
Wilson, James E.
Wolff, D. J.
Wood, C. A.
Pawnee
Echo-Hawk, Owen
Ponca City
Crawford, John M.
Culbertson, J. A.
Davis, Warren L.
de Witte, L.
Doty, William E. N.
Evans, Hugh, Jr.
Fickinger, D. E.
Flynn, Jack M.
Hughes, Roland F.
Jordan, C. K.
Kaufman, Hyman
King, Laurence K.
Lake, Charles L.
Moody, Herbert H.
Searcy, Frank
Swan, Bird G.
Van Nostrand, D. J.
Vorheis, Byron
Whitehead, L. E.
Prague
Klabzuba, Robert E.
Sayre
Rase, H. L., Jr.
Shawnee
Gibson, G. D.
Lukens, John P.
Moose, Dale H.
Schaeffer, Hugh C.
Smith, Delbert F.
Stillwater
Capps, Alden L.
Tulsa
Abel, Karl W.
Agocs, W. B.
Allen, Sam W., Jr.
Andrews, H. H.
Arnold, T. G.
Balbin, Paul D.
Ballou, Albert L., Jr.
Barthelmes, Albert J.
Barton, Jackson M.
Bazhaw, W. O.
Bearden, Carl D.
Benson, A. E.
Bevan, Thomas J.
Bills, Robert N.
Bishop, F. L.
Blakey, Carl W.
Borman, Frank W.
Born, Wm. T.
Boucher, F. G.
Bowie, Duncan M.
Breck, Howard R.
Brock, Charles D.
Brown, Frank E.
Brown, Henry W.
Brown, Paul B.
Buffum, C. Emery
Cady, Francis H.
Campbell, Francis F.
Carter, Norman A.
Cash, Harvey, Jr.
Christy, Robert F.
Clayton, Neal
Cochrane, David W.
Coffin, R. Clare
Connell, Joe E.
Cooke, Sam C., Jr.
Cooley, E. H.
Cooper, Jack R.
Coryn, F. R.
Cowell, Frank M., Jr.
Cronin, Stewart
Crump, W. W.
Crumrine, Kenneth C.
Cunningham, William J.
Damon, Everett F.
Davenport, Robert
Davis, D. R.
Dawson, L. Decker, Jr.
Day, Chas. E.
DeGood, R. G.
Denson, M. E., Jr.
Diamond, Paul E.
Dimmick, Opie
Doll, W. R.
Duller, Charles E.
Dunagan, Lillard C.
Dyk, Karl
Dzwons, George S.
Edmonson, Carl L.
Egan, Daniel G.
Eisler, Joseph D.
Ellsworth, E. W.
Engle, A. Wendell

Etnyre, John B.
Erdahl, William M.
Evans, David LeCount
Evans, Julian F.
Faust, L. Y.
Fearon, R. E.
Fentem, R. L.
Ferguson, John L.
Ferris, Craig
Finley, R. K.
Finn, Robert S.
Flemming, Howard
Foster, G. A.
Franklin, John V.
Friendly, Jack L.
Frossard, Robert L.
Frost, Noel
Garner, J. P.
Garpner, Erik U.
Gemmer, R. W.
Gilkinson, Don
Gilliam, J. T.
Gilmore, Robert James
Gilmour, Andrew
Giulio, Stanley E.
Goetz, Louis P.
Golosovker, S.
Green, Robert P.
Green, T. S.
Guntharp, John H.
Hachenberg, Charles D.
Hadley, Charles F.
Handley, E. J.
Harbach, Robert G.
Harlow, Robert O.
Harlton, Bruce H.
Harper, James C.
Harris, D. B.
Hartline, Ralph E.
Harvey, Castle J. C.
Hawes, Julian K.
Hays, Clyde L.
Heap, W. O.
Hidy, John H.
Holland, R. D.
Hollis, Jack L.
Hopkins, James S.
House, A. Maxwell
House, H. M.
Hurry, Clare N.
Ingalls, Philip C.
Ingle, Gerald W.
Innes, Arland I.
Jackson, Kenneth
Jackson, Judson G.
Jameson, Chet
Jeffers, Paul H.
Jewell, David F., Jr.
Jones, V. L.
Keeling, J. A.
Kendall, R. C.
Keselik, Joseph
Keys, Robert T., Jr.
Kezeler, J. L.
Kiess, Myron C.
Kimball, Jack E.
Kittredge, F. R.
Knowles, J. G.
Koeppel, B. W.
Lambkin, Woodrow W.
Lash, Charles C.
Lawrence, H. W.
Lawrence, K. M.
Laws, J. O.
Lea, Milton H.
Leas, Ruth R.
Lockard, L. F.
Locke, Edgar R.
Ludwick, C. C.
Lynn, Ralph D.
Lyons, Paul L.
Manhart, T. A.
Maras, Robert G., Jr.
Martin, Dick
Mathieson, Raymond L.
Maxey, J. R.
Mayes, Tom D.
McAlister, C. H.
McClure, C. E.
McCollum, E. V.
McCracken, Guy I.
McKenzie, D. B., Jr.
McManis, L. B.
McNatt, E. M.
Miller, James W.
Mills, Frank
Milton, A. A.
Mitchell, F. L.
Moore, Homer C.
Moore, Leland E.
Moore, Marion J.
Moore, W. Lee
Mossman, R. W.
Nash, Jno. M.
New, James R.
Newton, George R.
Novelly, Walter O.
Oliphant, Charles W.
Owen, H. E.
Owen, John E.
Palmer, John E.
Parker, G. A.
Patterson, A. R.
Peery, W. R.
Pennington, Wallace E.
Peterson, Glen
Peterson, V. A.
Phillips, J. W.
Pirson, Sylvain
Pool, Robert C., Jr.
Pottorf, Newell
Preston, B. G.
Price, Lee Hawke
Raborn, Smiley, Jr.
Ragan, Edgar D.
Rankin, C. T.
Reed, David E.
Reed, Geo. W.
Rees, Wesley W.
Reid, A. C.
Richardson, J. W.
Rickel, Wesley K.
Ricker, Norman
Riggs, R. J.
Roark, James J.
Roberts, P. E.
Robinson, William J.
Roemer, C. D.
Rollins, J. C.
Romberg, Marvin
Ross, C. M.
Ross, J. T.
Rummerfield, Ben F.
Rupnik, John J.
Rutledge, Richard B.
Schad, Charles A.
Schedler, George D.
Scherbatskoy, S. A.
Schmidt, Robert L.
Scott, C. B.
Sharpe, Joseph A.
Sibley, W. B.
Silverman, Daniel
Smith, E. F., Jr.
Smith, Frank B.
Southgate, Tom F.
Sparks, N. R.
Stafford, John A.
Stephens, T. V.
Stover, Edward B., Jr.
Strachan, Clyde G.
Swearingen, A. C.
Swift, Gilbert
Taylor, Albert
Taylor, Garvin L.
Teegarden, Tom
Thayer, J. M.
Thomas, Thomas J.
Thornton, Joseph W.
Thralls, H. M.
Van Orden, Keene C.
Vernon, Jess
Von Croy, Stefan
Warner, D. F.
Warren, Howard B.
Watson, Allan P.
Watson, Robert J.
Weatherby, B. B.
Weichert, David R.
Weichert, R. F.
Wells, W. M.
Westby, G. H.
Whitney, Vernon E.
Widess, M. B.
Wilcox, Stanley W.
Williams, P. S.
Williams, Richard
Wilson, James N.
Winn, Clayton N.
Winnek, J. R.
Zongker, Ray C.

Watonga
Strayhorn, Tom R.
Strozier, Orville
Strozier, Robert J.
Weleetka
Gregory, J. W., Jr.
Woodward
Barnes, R. H.

OREGON

Aurora
Lester, O. C.
Mt. Vernon
Culp, Harold A.

PENNSYLVANIA

Bethlehem
Gallagher, Robert T.
Maurada, Fred J., Jr.
Pentz, Harold H.
Pflueger, John C.
Bradford
Scholl, E. S.
Clearfield
Keenan, Curtis H.
Edensburg
Bender, Fred A.
Gibsonia
Fink, Paul O.
Greensburg
Galpin, Sidney S.
Madera
Capatch, Victor F.
Norwood
Bazzoni, Charles B.
Oakmont
Smith, Douglas H.
Whitley, Joseph M., Jr.
Palmerton
McMurray, Howard V.
Philadelphia
Meadow, Harold
Peterson, Eugene F.
Pittsburgh
Affleck, James
Allen, Frank T.
Allon, Michael
Aszklar, Stanley J.
Baade, John H.
Backman, John E.
Bailey, Lothrop H.
Barnum, Warren R.
Barton, Edward I.
Belt, George R.
Boardman, Dorothy M.
Butler, Mark D.
Cerveny, Philip F.
Cook, D. E.
Davis, David A.
Demshar, Ludwig S.
DeVos, Lawrence S., Jr.
Diveley, Paul R.
Eckhardt, E. A.
Elkins, Thomas A.
Gardner, Louis W.
Gealy, Wendell B.
Hammer, Sigmund I.
Hanrahan, Thomas N.
Hastings, W. K.
Hazen, William G.
Herron, Robert C.
Jensen, Homer
Jones, R. W.
Kilborn, J. M.
Lamb, William C.
McGrew, Harry J.
Melchior, Louis F.
Meszaros, W. A.
O'Donnell, T. J.
Palmer, E. M.
Palmer, Loyal D.
Peters, L. J.
Pomeroy, R. F.
Reiser, Robert C.
Robinson, John L., Jr.
Robinson, W. Bernhard
Ross, R. B.
Teague, M. W.
Thomas, Howard E.
Vitale, Robert P.
Watson, George R.
Wert, Carl M.
Wickerham, M. D.
Wigbels, Frank B.
Wyckoff, R. D.
Portage
Stuart, David J.
Ridley Park
Johnson, F. L.
State College
Cook, John C.
Howell, B. F., Jr.
Keller, George V.
Vozoff, Keeva
Verona
Bohanan, Wayne F.
Muffly, Gary
Williamsport
Dobrick, Edward G.
Harrison, E. V.

TENNESSEE

Oak Ridge
Banta, H. E.
Garrett, Geo. A.

TEXAS

Abilene
Crider, Lewis C.
Reeves, James N.
Tefft, Gerald H.
Amarillo
Siegfried, Richard C.
Andrews
Wright, John W.
Austin
Baker, Charles M.
Cross, James H.
Horton, C. W.
Hughes, Darrell S.
Jones, Charles R.
Romberg, Frederick E.
Thomas, Earl
Ballinger
McMahan, J. R., Jr.
Beaumont
Dodd, Lavon C.
Ellis, L. G.
Evans, William T.
Gammon, Orin Rex
Henson, Robert L.
Herman, Alvin J.
Hollingsworth, W. E.
Jantz, O. I.
Konz, Leo W.
McCalpin, George A., Jr.
McCormack, Harold R.
Millington, John W.
Noble, Francis H.
Richert, B. E.
Tillman, T. H.
Williams, C. E.
Winterhalter, Alfred
Beeville
Claunch, Elton B.
Jackson, R. S.
Bellaire
Cowles, Laurence G.
Happel, Henry H., Jr.
Herzog, Gerhard
Hibbler, A. J.
Hubby, L. M.
Jones, M. P.
Lee, B. D.
Manes, O. B
Mann, Ralph W.
Morris, H. B.
Pranglin, John A.
St. Germain, Raymond J.
Treybig, J. A.
Big Lake
Feather, John E.
Hoeninghaus, F. A., Jr.
Martner, Samuel T.
McReynolds, P. T.
Valder, Clayton S.
Voelker, H. L.
Big Spring
Barnes, Chester F.
Mataya, Jack L.
Rowe, Ural A.
Wardell, Richard H.
Whiting, Gertrude R.
Brownfield
Bixby, Robert H.
Brownwood
Salyer, James L.
Carrizo Springs
Christman, Albert J.
Center
Ruhlen, W. W.

Childress
Shannon, Charles A.
Cisco
Hart, M. M.
Reeves, James R.
Coleman
Cheney, M. G.
College Station
McDowell, A. N.
Weekes, Donald F.
Colorado City
Bierend, Frank J.
DeJournette, R. D., Jr.
Dick, Charles W.
Columbus
Etheridge, K. E.
Corpus Christi
Barber, Thomas D.
Bolinger, John W.
Daugherty, C. G., Jr.
Gallaway, R. L.
Howerton, Bert
Macdonell, M. E.
McCaleb, Maurice M.
Nelson, James K.
Randolph, J. R.
Reivere, Romaine
Starr, A. G.
Stouse, Maurice J., Jr.
Teasley, Samuel A.
Zazvorka, Jerry, Jr.
Cotulla
Morrison, Edward
Crowell
Sprinkle, Don L.
Dalhart
Davidson, G. Bowen
Gibbs, Kenneth E.
Dallas
Acrey, Donald O.
Agnich, Fred J.
Alcock, E. D.
Amis, W. H., Jr.
Anderson, Russell W.
Andrews, Reagan H.
Archer, Milton
Armstrong, Orven H.
Arnett, R. D.
Arnold, Kingsland
Augenthaler, R. L.
Autrey, C. B.
Ayres, J. Otis
Baker, M. E.
Blattner, Sanford D.
Bonebrake, Walter C.
Boulware, Robert A.
Brannian, Ross E.
Brock, Fred A.
Broding, Robert A.
Brown, H. Hallock
Burg, K. E.
Bussard, William H.
Byers, Richard E.
Campbell, E. L.
Capp, J. T.
Carpenter, Michael C.
Carrow, James O.
Cathey, John A.
Chamberlain, Chester W.
Clewell, Dayton H.
Clifford, O. C., Jr.
Cloepfil, Gordon D.
Cobb, Howard L.
Collingwood, D. M.
Congdon, R. L.
Conklin, Glenn M.
Conover, George E.
Cortes, H. C.
Coursey, W. D.
Dahm, C. G.
Deford, H. L.
DeGolyer, E. L.
DeLoach, Edward L.
Dobrin, Milton B.
Dobyns, D. R.
Donnally, Chester J.
Douglas, Norvel
Dugan, Albert F.
Dundon, Robert
Dunlap, H. F.
Dunlap, R. C., Jr.
Earl, John H.
Eichelberger, A. M., Jr.
Eley, James C.
Elliott, Clinton H.
Elston, Chris H.
Everett, R. D.
Everitt, J.
Fain, Edgar A.
Farrow, B. D.
Finch, Elmer H.
Fisher, Guy W.
Fisk, F. K.
Floyd, Roy
Foote, Lewis C.
Frost, H. H.
Fuller, Roy Lee
Gaither, Jerrel
Gallacher, John D.
Garrett, M. M.
Gary, James W.
Geer, J. T.
Giles, Ben F.
Gill, John D.
Gillin, Jno. A.
Godbey, John K.
Godell, John J.
Graham, Leroy G.
Granberry, H. E.
Green, Cecil H.
Green, John W.
Green, W. G.
Griffin, W. Raymond
Gsell, R. N.
Guipre, Robert W.
Gunter, John R., Jr.
Haggarty, Patrick E.
Harkey, W. J.
Harkness, T. O.
Harvey, William P.
Hawk, Riddell L.
Hawthorne, W. W.
Hayes, Andrew J.
Hayes, Quinlivan
Haynes, C. G.
Heaps, Stanley
Heggy, Homer L.
Henderson, J. B.
Henderson, Oran C.
Henderson, Ross
Henkel, John H.
Heroy, W. B.
Heroy, William B., Jr.
Hieatt, Herbert F.
Hightower, C. H.
Hill, Delmar E.
Hodge, P. V.
Hogg, W. B.
Holbert, Murrell
Holmes, Odie M.
Horn, J. W.
Howard, Ben R.
Howard, Geo. A.
Imle, John F.
Isensee, George W.
Jasinski, E. J.
Johnson, Lloyd
Jonsson, J. E.
Jopling, D. W.
Karcher, J. C.
Kelsey, Martin C.
Kennedy, Edward P.
Kennedy, Frank H., Jr.
Kern, Jack C., Jr.
Kiesler, Ernest A.
Kovelan, Edward C.
Kyle, Ramon
Lawrence, Philip L.
Lester, John A.
Leventhal, Stanley M.
Linwell, Martin V.
Lipscomb, Earl W.
Lipson, Leonard B.
Lodge, James T.
Loftin, R. T., Jr.
Logue, L. L.
Lohrentz, Don
Lomax, Carl J.
Loyd, Edward R., Jr.
MacNaughton, L. W.
Marshall, Harold D.
Martin, John L.
Mayhew, Charles M.
McBurnett, Harry, Jr.
McBurney, C. G.
McCain, Hugh, Jr.
McCarver, Holland C.
McDermott, Eugene
McFadden, Darragh H., Jr.
McGiboney, James C.
McKay, A. E.

McClaod, Kenneth W.
McManus, Jack V.
McMullin, Elbert F.
Megason, Leland G.
Menefee, James C.
Milstein, Mark
Minton, J. P.
Mitchell, W. R.
Molinar, J. J.
Moon, Jake
Moore, F. A.
Moran, Ray O.
Morgan, Charles Gili
Morton, A. G.
Myers, John R.
Napier, T. S.
Nash, Paul E.
Neece, Neal, Jr.
Newton, W. W.
Nogami, Henry H.
Nugent, Roderick M.
Oden, A. J.
Oksa, Donald R.
Olson, R. W.
Ownby, Byron
Paslay, L. C.
Peacock, H. B.
Pellillo, M. J.
Penn, Edgar R.
Pernell, J. H.
Perryman, J. D.
Peters, Jack W.
Peterson, K. E.
Pittman, C. V. A.
Porter, C. P.
Price, J. V.
Ralph, Pierson M.
Ransom, J. H.
Ransone, W. R.
Reagor, Edward C.
Renner, Darwin S.
Rettger, Robert E.
Robinson, Thomas E.
Rollins, J. Frank
Roper, W. B.
Rosaire, E. E.
Rose, H. W.
Rouse, John T.
Russell, Dallas L.
Sadler, John W.
Sandusky, P. M.
Sanford, Robert E.
Seiler, Geo. E.
Shook, Earley M.
Shugart, T. R.
Smith, A. Horton, Jr.
Smith, Charles W.
Smith, Randolph
Smithwick, H. B.
Sole, Lewis H.
Sorrels, B. J.
Spivey, Calvin J.
Stanfield, J. W.
Steel, D. M.
Stehr, Raymond A.
Stephens, J. L.
Stulken, E. J.
Summers, Gerald C.
Tottenham, W. M.
Swanson, Jack G.
Thompson, James E.
Towles, Henry C., Jr.
Trostle, T. D.
Tronrud, Roy W.
Valkus, James W.
Van Cleave, Robert F.
Waller, John A., Jr.
Walsh, T. N.
Walter, C. G.
Walton, B. W.
Walton, Paul L.
Warrick, Thomas R.
Waters, Kenneth H.
Wayland, J. R.
Weisbrich, R. A.
White, Gale
White, J. E.
Whorton, L. P.
Williams, Charles C.
Williams, Floyd J.
Wissemann, Hilmer J.
Wodrich, Frank W.
Woodall, Sherrill O.
Woods, J. P.
Woolley, William C.
Yost, W. Jacque
Zivney, James R., Jr.
Zwiebel, George H., Jr.

El Campo
Dominy, D. D.

Floydada
Arnold, W. S.

Ft. Worth
Anderson, Owen Wm.
Baird, Walter D.
Campbell, David Bell, Jr.
Childress, Kay H., Jr.
Dana, R. H.
Donley, John C.
Dudley, R. W.
Gemmill, Edward J.
Harrell, J. G.
Harrington, G., Jr.
Harris, Sidon
Hill, Emmett T., Jr.
Hollingsworth, W. W.
Itten, Howard
Johnson, James F.
Kerbow, R. B.
Kerr, V. Robert
Kunkel, T. L.
LaNeve, R. O.
Lang, R. H.
Ledyard, Paul H.
Lockett, Gwendolyn P.
Long, C. J.
Lovejoy, J. B.
Mayo, H. B.
McLemore, Ethel Ward
Mitchell, James R.
Morehead, Jack N.
Morris, James L.
Mortlock, F. O.
Normand, Spencer R.
Parks, Robert R.
Payne, C. Win
Riley, James K.
Sanders, C. W.
Schouten, F. H.
Seaman, L. O.
Simpson, Lee
Smith, Roy O.
Suggs, Millard L.
Van Steenbergh, S. K.
Warren, Kirby J.
Welboan, J. S., Jr.
Wilson, John H.
Wilson, John H., II

Gainesville
Boring, Burl J.

Garland
Baker, Buford M.
Stanton, Austin N.
White, R. H.
Winn, Billy

Goliad
Hargis, A. V.

Grand Prairie
Livingston, H. Raymond

Grand Saline
Jones, Edward C.

Grapevine
Deacon, L. E.

Greenville
Pincomb, E. M.

Hallettsville
Rucker, James H.

Hamilton
Stiles E.

Houston
Adler, Joseph L.
Akkerman, Richard Pete
Allen, Stanley R.
Anderson, John F.
Andrews, W. W.
Arthur, M. A.
Athy, L. F.
Bader, Glenn E.
Barbisch, J. B.
Bartlett, David
Bartow, Arthur I.
Beeman, Keith R.
Beeth, Donald
Bell, Olin G.
Bemrose, John
Benke, M. L.
Bennett, Roy F.
Berg, G. A.
Berleth, William H.
Bertram, A. C.
Bible, John L.
Bird, Ross H.

Black, J. P.
Blau, L. W.
Bohannon, Milton A.
Boudreaux, Edward A.
Bratton, D. J.
Braud, Nolan J., Jr.
Briard, Vernon E.
Briggs, Robert B.
Brooks, James A.
Broussard, C. H.
Broussard, D. F.
Brown, Andrew
Brown, Hart
Buckner, Guy O.
Bunsen, A. W.
Burke, William H., Jr.
Burkhalter, H. L.
Burnett, A. C.
Butler, Robert E.
Butler, W. W.
Byers, John W.
Campbell, H. H.
Carlton, Dave P.
Catchings, Robert F.
Chappell, Clifford M.
Charrin, Paul J. D.
Charske, Charles J.
Chernosky, Allen A.
Child, V. E.
Christman, A. J.
Clark, George B.
Clark, W. O.
Cloud, R. T.
Cook, Paul C.
Cornelison, Boyd
Cram, Ira H.
Crary, Donald
Crowder, H. V.
Crowell, J. H.
Dauphin, W. D.
Davis, Donald M.
Deussen, Alexander
Dunway, J. H.
Duty, Robert S., Jr.
Duty, W. B.
Eby, J. Bryan
England, Carroll M.
Farren, Paul
Fay, Charles H.
Feagin, Frank J.
Fennessy, W. J.
Ferguson, J. B.
Ferguson, Joe L.
Fielder, C. K.
Fishback, Joseph W.
Flude, J. W.
Fohs, F. Julius
Franklin, Louis
Freel, J. F.
Frosch, A.
Frowe, Eugene
Fuller, John C. J.
Gaither, H. L.
Gardner, Derry H.
Garrett, William M.
Geyer, Richard A.
Gibson, W. H.
Giezendanner, S. S.
Gilliland, J. R.
Goldstone, Frank
Goss, Henry V.
Gould, Martin J.
Grange, Donald C.
Griffin, I. M., Jr.
Guiler, Mona D.
Guyod, Hubert
Hafner, W.
Hagen, Cecil
Hale, E. M.
Hall, T. O.
Hamil, A. B.
Hamilton, W. Brooke
Hammial, L. L.
Hanahen, P. M.
Hans, Edward
Happel, Henry H.
Harbough, Allan W.
Harkins, Curtis P.
Harkins, T. I.
Hatcher, Stanley A.
Haynes, C. J.
Haynes, R. B., Jr.
Heintz, Karl O.
Henderson, M. R.
Henquet, R.
Hermont, Alfred J.
Hess, Edith May
Hibbler, M. E.
Hill, E. Bruce
Hilton, R. C.
Hinson, Cecil C.
Hoard, J. O.
Hocker, Otis B.
Holland, Taylor Hugh
Horvitz, Leo
Howell, Lynn G.
Hubbard, Charles L.
Hubbert, M. King
Hull, J. W.
Hunzicker, A. A.
Hutchinson, C. C.
Irwin, W. L.
Ivy, John S.
Jackson, G. L.
Jackson, Jim C.
Jett, J. E.
Johnson, Earle W.
Johnson, Frank B.
Johnson, W. D.
Jones, E. E.
Jubran, Joseph R.
Judson, Sidney A.
Kannestine, F. M.
Kaufman, Sidney
Kendall, John W.
Kimes, Albert
Klaveness, A.
Koury, Barton H.
Krause, Fred W.
Krieg, E. A., Jr.
Kriegel, H. C.
Kubik, Kasmier D.
Ladner, A. L.
Lamb, George B.
Larguier, L. J.
Larue, James E.
Lawhorn, O. T.
Lay, Roy L.
Lea, W. T.
Lee, W. B.
Leonardon, E. G.
Lewis, W. B.
Long, G. J.
Lowe, C. R.
Lowery, R. A.
Mace, G. M., Jr.
MacMahon, A. M.
Marr, John D.
Martin, E. D.
Martin, Sidney A., Jr.
Martyn, Phil F.
McCann, K. G.
McCollum, Burton
McCreary, Dosh T.
McCullagh, John, Jr.
McDonnold, H. W.
McGee, John E.
McReynolds, Gregg F.
Melton, D. P.
Miller, Robert D.
Millet, M. J.
Mitchell, George D., Jr.
Monkhouse, John R.
Montgomery, Geo. P., Jr.
Montgomery, J. C.
Moore, D. B.
Moore, James M.
Moore, James R., III
Morgan, Wesley H.
Mott Smith, L. M.
Mounce, W. D.
Mower, L. K.
Murrell, James T.
Myers, Charles E.
Neese, U. E.
Nelson, William P.
Nettleton, L. L.
Neuman, L. J.
Newby, C. J.
Nichols, J. B.
Noonan, W. G., Jr.
Nutt, W. T.
Ording, J. R.
Ostreim, R. N.
Palmer, R. L.
Parker, John C.
Parker, Kenneth L.
Parker, L. A.
Parker, Richard H.
Paschall, John P.
Patrick, H. G.
Pawley, Julian K.

Pena, Sam M.
Petersen, H. C.
Pollard, Jack C.
Pollet, Arthur
Postma, G. W.
Powell, Paul B.
Prescott, H. R.
Quarles, Miller, Jr.
Randle, Sam, Jr.
Rasco, William A.
Ray, Robert H.
Reed, Chas. F.
Reid, William, Jr.
Reynolds, F. F.
Rivers, Henry F., Jr.
Roberts, R. D.
Robinson, Edwin H.
Rockwell, G. O.
Rogers, Austin S.
Rogers, L. Brann
Rogers, Revill M.
Rogers, Sam D.
Rolshausen, F. W.
Rosaire, C. G., Sr.
Rulfs, G. W., Jr.
Rusch, Peter J.
Ruska, Walter
Rust, W. M., Jr.
Rutherford, Robbie
Sappington, Chester
Sargent, R. L.
Saville, W. G.
Schafer, Sidney
Schander, J.
Schmidt, Henry
Schmuck, R. H.
Schofield, G. A.
Scholl, Louis A., Jr.
Schorre, Bartholme
Schumacher, J. P.
Sears, Harold A.
Selig, A. L.
Sheets, Martin M.
Sherar, E. S.
Sherar, Stuart
Shettle, George O.
Shimek, E. J.
Shore, Harold F.
Sims, Sam E.
Slotnick, M. M.
Smith, A. E.
Smith, A. L.
Smith, Fred A.
Smith, H. C.
Smith, J. Angelo
Smith, Noyes D.
Smith, Warren H.
Somers, George B.
Speckels, Arthur W.
Spencer, J. S.
Stauffer, Arthur L.
Steele, W. E., Jr.
Steenland, N. C.
Stewart, S. B.
Stone, Geo. B.
Stratton, E. F.
Sweet, R. C.
Talley, H. C.
Taylor, Josiah
Taylor, W. Harlan
Terrasson, Paul L.
Thackston, Warren C., Jr.
Thomas, Dick L.
Thompson, K. C.
Thompson, R. P.
Tilley, G. E.
Treybig, B. H., Jr.
Tucker, Robert L.
Urban, L. M.
Van Auken, John A.
Van Melle, F. A.
Vreugde, L. M. H.
Vreugde, T. L. J.
Wallace, C. R.
Wallace, Frank R.
Walling, Ray W.
Watt, J. S.
Weatherburn, K. R.
Weaver, Paul
Weingartner, R. A.
Wilber, Roscoe C.
Williamson, Lonnie C., Jr.
Wilson, E. E.
Wingett, R. O.
Winter, A. B.
Winter, George W.
Wolf, Alexander
Worden, Sam P.
Wright, Fred E.
Wright, Ray H.
Yeates, F. L.
Yokubaitis, A. C.
Zagst, E. F.
Zavoico, Basil B.
Zimmerman, C. C.
Zirbel, N. N.

Huntsville
Adams, Leland C.
Hurt, W. B.

Irving
Carson, Roe W.
Horn, Russell E.
Luehrmann, William H.

Jacksonville
Huff, Allen L.
McKinley, William D.

Jasper
Pirsig, Gerald F.

Junction
Opitz, E. E.
Watts, Evan

Kingsville
Edmonson, J. W. E.

Lamesa
Lund, Floyd T.

Lockhart
Notley, W. E.

Lubbock
Black, Robert J.
Epperson, R. S.
Garrison, Phil H.
Harman, Duane G.
Hughes, J. C.
Kendrick, Harold Landis
Klaus, Hellmut
Lamm, Robert J.
Morrison, M. S.
Pluta, Joseph S.
Smith, C. C.
Willcockson, J. R.

Marshall
E. E. Brown

McAllen
Harris, B. A.
Wilson, William H.

Mertzon
Walling, F. Rex

Midland
Arick, M. B.
Barron, Charles E.
Blake, E. F.
Borys, Edmund
Bradley, H. W.
Breedlove, Ruth
Burton, Raiford H.
Conant, E. E.
Cornell, Russell B.
Cornish, Lou G.
Davis, R. E.
DiGuilio, Fred J.
Feather, V. G.
Fischer, Leon
Forward, Fred
Gibson, George R.
Grafton, W. Dean
Grimm, George A.
Homan, W. L.
Hubner, B. G., Jr.
Jackson, O. B.
Jasper, Walter E.
Lemaster, Randall R.
Martin, G. W.
McKinsey, M. H.
McNally, P. M.
Mehringer, A. P.
Miller, Jeff E., Jr.
Mims, Robert L.
Mount, E. L.
Ott, Lawrence N.
Owings, B. F., Jr.
Ozman, Dale D.
Page, C. Newton
Park, Lee B.
Park, Noel R.
Percy, C. G.
Porter, James C.
Rabensburg, N. J., Jr.
Ricketts, E. L.
Ross, W. T.
Rugg, Allen M., Jr.
Shoup, George

St. Clair, D. W.
Shock, Lorenz I.
Stone, Robert C.
Swords, Henry L.
Thompson, Roy W.
Uhrig, Leonard F.
Unger, Earle E.
Warren, R. P.
Wicker, Marshall C.
Winn, C. L.
Winter, Niles B.

Mineola
Callahan, Janie L.

Mt. Pleasant
Mouche, Theodore J.

Muleshoe
Hannum, W. L.

Odessa
Davis, L. A.

Orange
Arsenault, Charles A.
Shor, George G., Jr.

Palacios
Sisson, H. H.

Pecos
Scott, D. L.
Toliver, Billie Alfred

Plainview
Mickey, Wendell V.
Shivers, G. C., Jr.
Stacy, E. L.

Port Arthur
Pentecost, Claude D.

Post
Mason, Marshall, Jr.

Rio Grande City
Patton, C. E.

Riverside
Weinzierl, J. F.

Rocksprings
Harris, John

Rosenberg
Foote, Wm. Logan

San Angelo
Glover, George D.
Green, Howard W.
Hunt, Eugene Windell
Lawrence, William P.

San Antonio
Allen, Thomas L.
Barksdale, Gerald L.
Bennett, Elwin
Bissett, Clark
Carter, Ray K.
Crawford, Paul D., Sr.
Crawford, W. L.
Dawson, Herbert M.
Donnelly, V. T.
Gragnon, Joseph N.
Hathaway, M. S.
Hemmi, C. W.
Hunzicker, Vernon J.
Kelley, W. W.
Kirby, A.
Kohler, A.
Langford, Eldon W.
McClellan, Oliver
McDaniel, C. M., Jr.
Narvarte, P. E.
Ohman, John
Parr, J. O., Jr.
Petty, Dabney E.
Petty, O. S.
Petty, Van A., Jr.
Pratt, R. B.
Proctor, John L.
Ratliff, Guy M.
Roberts, Homer E.
Rudolph, P. J.
Rumsey, Paul T.
Russell, Jim
Schmidt, Karl H.
Smitherman, Lynn A.
Smyrl, H. B.
Snow, Leland
Souther, J. B.
Weatherby, S. P.
West, Thomas S.
White, H. Paul
Wright, J. Dexter

San Benito
Russek, I. W.

Seguin
Blumberg, Roland K.

Seminole
Hartenberger, Royal A.
Walz, Harry B.

Sherman
Hendricks, J. L.
Schiflett, H. L.

Sinton
LaRue, W. W.
Tidwell, Ellis M., Jr.

Slaton
Heard, James R.
Keese, James D.

Smithville
Grizzell, E. I.

Snyder
Reed, Paul C.
Van Siclen, DeWitt C.

Spur
Buckingham, W. T.

Stanford
Gilmore, Robert A.

Sunray
Hardison, Stanley G.

Sweetwater
Horton, John D.
Patterson, Harold F.

Tahoka
Evans, Bobby L.
Faubion, Charles G.

Three Rivers
Dexter, Laurence N.

Tyler
Brooks, O. D.
Durham, Charles A.
Flowers, Jack F.
Hale, R. B.
Throop, W. H.

Waco
Jett, Glendon D.

Waxahachie
Bean, Robert J.
Shackelford, Lewis L., Jr.

Wichita Falls
Bradley, Joe R.
Crain, Robert A.
Gilmore, John A.
Mayfield, William I.
McReynolds, Oliver B., Jr.
Mitcham, F. M., Jr.
Neff, W. D.
Samford, Mack
Strong, J. Randolph, Jr.
Weeth, Chas. A.

Woodville
O'Brien, Decatur

Yoakum
Autrey, D. W.
Clark, W. C.
Eakin, Carl
McGuckin, Glenn M.

UTAH

American Fork
Sargis, S. G.

Bountiful
Mabey, Don R.

Ft. Douglas
Roller, John C.

Kamas
Zieve, Robert L.

Salt Lake City
Bauer, Robert W.
Cook, Kenneth L.
Doan, Raymond E.
Donohoo, H. V. W.
Hayes, Junius J.
Knittle, Richard Brooke
Lacy, R. J.
Lamon, Robert S.
Larsen, Kenneth W.
Marquardt, Carlton M.
Novak, Daniel J.
O'Toole, Walter L.
Smith, Darrell E.
Willmore, N. W.

Vernal
Rupert, James W., Jr.

VIRGINIA

Alexandria
Lipson, Edward

Arlington
Perkins, B., Jr.

Yorktown
Prade, Nat. H.

WASHINGTON

Bremerton
Dausman, R. H.
Quincy
Neibauer, Herman
Seattle
Bowlby, Clarence W.

WEST VIRGINIA

Huntington
Kitchen, James H.

WISCONSIN

Madison
Woollard, George P.
Platteville
Cummins, Earl L.

WYOMING

Alcova
McCleary, Henry G.
Casper
Boggs, William E.
Desmond, J. M.
Durant, C. P.
Ellsworth, Frank
Ervin, Lynn D.
Fenwick, Willis H.
Greenlee, Paul
Hawpe, Franz M.
Heim, Jean W.
Hoffman, John C.
Hostetter, William N.
Junger, Arne
Lankton, John M.
Larson, Carl L., Jr.
Martin, Jack
McCoy, J. H.
McGrady, Dupree
Parker, John M.
Partridge, J. F., Jr.
Petsoff, George J.
Roberts, Grant M.
Schlundt, Herbert
Schombel, L. F.
Strange, O. A.
Travis, Fred L., Jr.
Van der Weg, Klaas
Walczak, Michael J.
Whitt, Rayburn H.
Wilkinson, A. L.
Winfrey, D. B.
Douglas
Schuster, G.
Gillette
Clement, Paul F.
Lander
Williams, E. D.
Lusk
Pierce, Jack M.
Stafford, C. J.
Newcastle
Martens, W. B.
Rawlins
Johnston, Frank M.
Riverton
Eastes, William T

FOREIGN

AFRICA

Portuguese East Africa
Mozambique
Barbour, P. C.
Heggblom, J. C.

North Africa

French Morocco
Taranger, Pierre

Tunisia

Sfax
Dresbach, C. H.
Tunis
Mrosovsky, P.

South Africa

Johannesburg
Kaplan, G. S.
Lowenstein, N.
Paver, G. L.
Sorour, G. L.
Weiss, Oscar
Pretoria
Enslin, J. F.
Maree, B. D.

Rhodesia

Filabusi
Fletcher, H.

Transvaal

Benoni
Garwood, Peter
Goodman, Joseph
Witbank
Blumberg, H. J.

South West Africa

Tsumeb
Berning, J.

West Africa

Nigeria
Walls, Robert

ALASKA

College
Heppner, James P.
West, S. S.
Fairbanks
Luhrs, Lawrence B.
Spittel, Robert J., Jr.
Woolson, John R.

ARABIA

Dhahran
Garvey, Thomas A.
Hotchkiss, H. C.
Reed, I. J.
Seager, O. A.
Sharp, C. Sheldon
Spivey, Sherman R.
Storm, Alfred E.
Zimerman, Sam

AUSTRALIA

New South Wales
Adkins, George E.

BELGIUM

Brussels
Brognon, G.
Evrard, Pierre

BORNEO

Seria Brunei
Jackson, J. B.

BRITISH WEST INDIES

Trinidad
Higgins, G. E.

CANADA

Alberta

Calgary
Acheson, C. Harold
Armstrong, John A.
Babb, John J.
Barnes, A. L.
Bediz, P. I.
Bickel, Harold C.
Bigelow, D. V.
Black, William D.
Blundun, G. J.
Bradford, M. D.
Brockway, L. I.
Brooks, Robert H.
Castelli, L.
Chaput, U. J.
Chesher, C. E.
Christie, Norman J.
Cook, E. T.
Copeland, R. J.

Cressman, K. S.
Dahse, Clem A.
Daniel, Robert E.
Dissler, Ernest W.
Doe, Robert
Downey, Hugh P.
Dunlap, A. D.
Farmilo, A. W.
Gaby, Phil P.
Galloway, John O.
Gerrard, J. A. F.
Gibson, G. G.
Hajash, G. M.
Halbrook, T. A.
Harper, W. L.
Hess, G. R.
Hohag, Walton H., Jr.
Houghton, H. M.
Kidder, Harold J.
Kochendorfer, A. J.
Koenig, Robert J.
Leedy, F. B.
Legge, J. A., Jr.
Lockwood, Robinson P.
MacAllister, C. T.
Mace, H. G.
Macon, Curtis E.
Maliphant, H. C.
Marble, Kennedy R.
Matthews, William A.
McKeever, J. H., Jr.
Mett, D. R.
Mills, Robert G.
Moody, N. K., Jr.
Moore, Charles M., Jr.
Morris, Margaret L.
Myers, Wm. Howard
Nicol, A. J.
Northwood, E. J.
Ogilvie, Wm. P.
Olson, C. H.
Peacock, Robert H.
Pearson, S. G.
Phares, Wayne A.
Procter, John E.
Rabey, W. N.
Rainey, Richard H.
Rankin, Wm. K.
Reese, Weiman H.
Reeves, W. A.
Richards, L. J.
Robertson, K. A.
Robertson, W. A.
Rogers, Milton H.
Rozsa, T.
Rutledge, E. E.
Sargent, D. M.
Schultis, G. E.
Siegel, Frank
Schwab, Robert
Sosnowski, J.
Stephenson, R. W.
Stoneman, Harold W.
Strangman, W. E.
Tucker, M. D.
Vallat, E. H.
Walker, J. E.
Weisser, G. H.
White, S. A.
Ziegler, J. K.

Camrose
Porter, Hugh, Jr.

Cardston
Bates, A. D.

Drumheller
Bowden, J. W.
Gontarek, M. D.

Edmonton
Alvey, G. C.
Burns, J. L.
Bush, James H.
Deutsch, Ernst
Ellis, Robert L.
Fetzer, Edwin L.
Hobson, George D.
Johnson, C. S.
Keller, Ray F.
Major, W. J.
Mayfield, Ira C., Jr.
McKee, W. A.
Pallister, A. E.
Reingans, G. A.
Rhymes, J. W.
Sargent, D. M.
Selmser, Calbert B.
Shell, Horace E.
Tellington, W. J.
Wolikowski, Andrew
Zimmerly, Richard F.

Forestburg
Walker, Donald J.

High Prairie
Albers, W. F.

Peace River
Barthelemy, J. E., Jr.
McDougall, D. B.
Shaller, Robert B.

Sexsmith
Kinsley, E. R.

Stettler
Gaede, John E.
Proffitt, Jack M.

Montreal

Westmount
Reford, Michael S.

Nova Scotia

Truro
Blanchard, J. E.

Ontario

Copper Cliff
Smith, A. R.
Squires, Robert H.
Taylor, Ron R.

Ft. William
Hayes, James O.

Hamilton
MacMillan, John A.

Lansing
Harris, Ronald Frank

Larder Lake
Middleton, B. M.

London
Uffen, Robert J.

Long Branch
Allenby, Richard J.

Ottawa
Hodgson, Ernest A.
Hodgson, John H.

Toronto
Boyd, Frederick C.
Brennan, D. F.
Britton, John W.
Cameron, Robert A.
Cartier, W. O.
Clifton, Frank T.
Dowsett, John
Garland, George D.
Harvey, H. A.
Hudson, J. Drew
Johnson, A. E.
Johnson, G. R.
Keefe, John A. C.
Lundberg, Hans
Manchee, Eric Best
McCamus, Frank W.
Morley, L. W.
Paterson, Norman Reed
Prendergast, Joseph B.
Ratcliffe, John H.
Salt, Donald J.
Sproule, John C.
Walter, John Patrick
Ward, Stanley H.
Westrick, E. W.
Wilson, William Thomas
Yazici, E.

Quebec

Bourlamaque
Brown, Frederick Wallace
Randell, John T., Jr.

Quebec
Faessler, C. W.

Val d'Or
Brossard, Leo
Koulomzine, T.

Saskatchewan

Regina
Adams, Hal R.
Beck, A. F.
Bychok, Victor
Chapman, C. J.
Dodson, Herbert F.
Klett, Richard C.
McGee, N. W., Jr.

EGYPT

Cario
Barkouky, A. N.

ENGLAND

Ayesbury Bucks.
Wilkinson, Robert P.
Bristol
Tonkin, G. P.

Herts

St. Albans
Tait, G.
Liverpool
Walls, Robert
London
Bourne, I. C. J.
Campbell, Francis J.
Coster, H. P.
Davies, Richard
Fitch, A. A.
Heads, John
Jehan, M. C.
Lindsey, E. B.
Makowiecki, L. Z.
Malone, Adam B.
O'Brien, Terence
Richards, T. C.
Robertshaw, Jack
Twardowski, Czestaw
Van Bekkum, J. J.
Van Der Linden, E. J. P.
Winstanley, Oliver B.
Zarudzki, E. K. F.

Berks

Wokingham
Pereria, J.

Notts

Near Newark
Germain-Jones, D. T.
Tarrant, L. H.
Kirklington Newark
Wyrobek, S. M.

Salop

Church Stretton
Bartlett, C. R. O.

ETHIOPIA

Dire Dawa
Cornett, J. R.

FINLAND

Pargas
Metzger, Adolf

FRANCE

Montpellier
Mainguy, M.
Paris
LeBlanc, Jacques
Maillet, Raymond J.
Migaux, Leon
Schlumberger, Marcel
Sundt, Olaf F.
Pau Basses-Pyrenees
Dienesch, Jean

GERMANY

Barbis Harz
Stackler, William
Barkhovenalle
Mintrop, L.
Berlin
Stubbe, G.
Göttingen
Schulze, Gustav-Adolf
Hannover
Schleusener, Alfred
Serchsen
Kaselitz, Fritz

HOLLAND

Geleen
Van Riel, W. J.
The Hague
Augusteijn, J. J.
Baars, Bastiaan
Brown, Donald R.
DeBruyn, J. W.
Klein, Haneveld, A.
Koefoed, O.
Ulrich, Victor P.
Van Weelden, A.
Oldenzaal
deBlank, B.
Hartmann, P. C. P.

ICELAND

Reykjavik
Bodvarsson, Gunnar

INDIA

Bombay
Mehta, P. E.
Calcutta
Hazra, P. C.
Rao, M. B. R.
Poona
Banerjee, Santilal

IRAN

Masjik I-Soleiman
Tuman, V. S.

IRAQ

Basrah
Woodburn, James E.

IRELAND

Belfast
Reid, Thomas J.

ISRAEL

Kfar Shmaryahu
Loehnberg, Alfred
Rehovath
Pekeris, C. L.
Seabrooke, D. S.

ITALY

Milano
Bossolasco, Mario
Heaney, Don B.
Parma
Rocco, T.
Perugia per Prepo
Belluigi, Arnaldo
Rome
Dessau, Gabor
Selem, A. M.

JAPAN

Kanagawa-ken
Iida, Kumiji

LEBANON

Tripoli
Banta, N. H.
Colley, G. C.

FEDERATION OF MALAYA

Perak
Alexander, J. B.

MEXICO

Mexico City
Aldredge, R. F.
Alvarez, Manuel, Jr.
Barclay, Stewart
Guseman, L. F.
Kohler, G. J., Jr.
Moedano, G. H.
Ortiz, Thomas
Rockwell, Donald W.
Rojas, A. Garcia
Schoellhorn, Henry, III
Schoellhorn, S. Wm.
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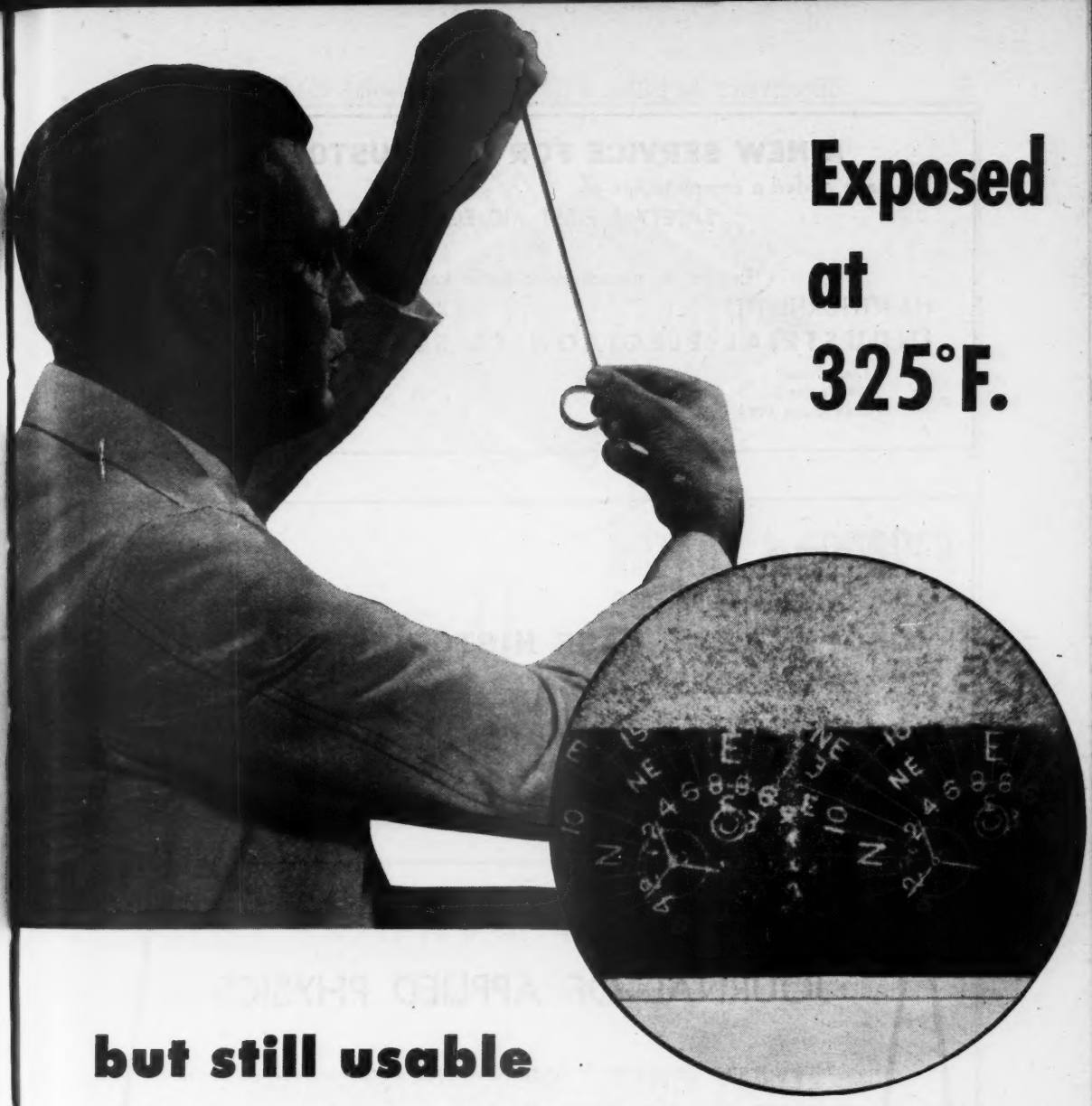

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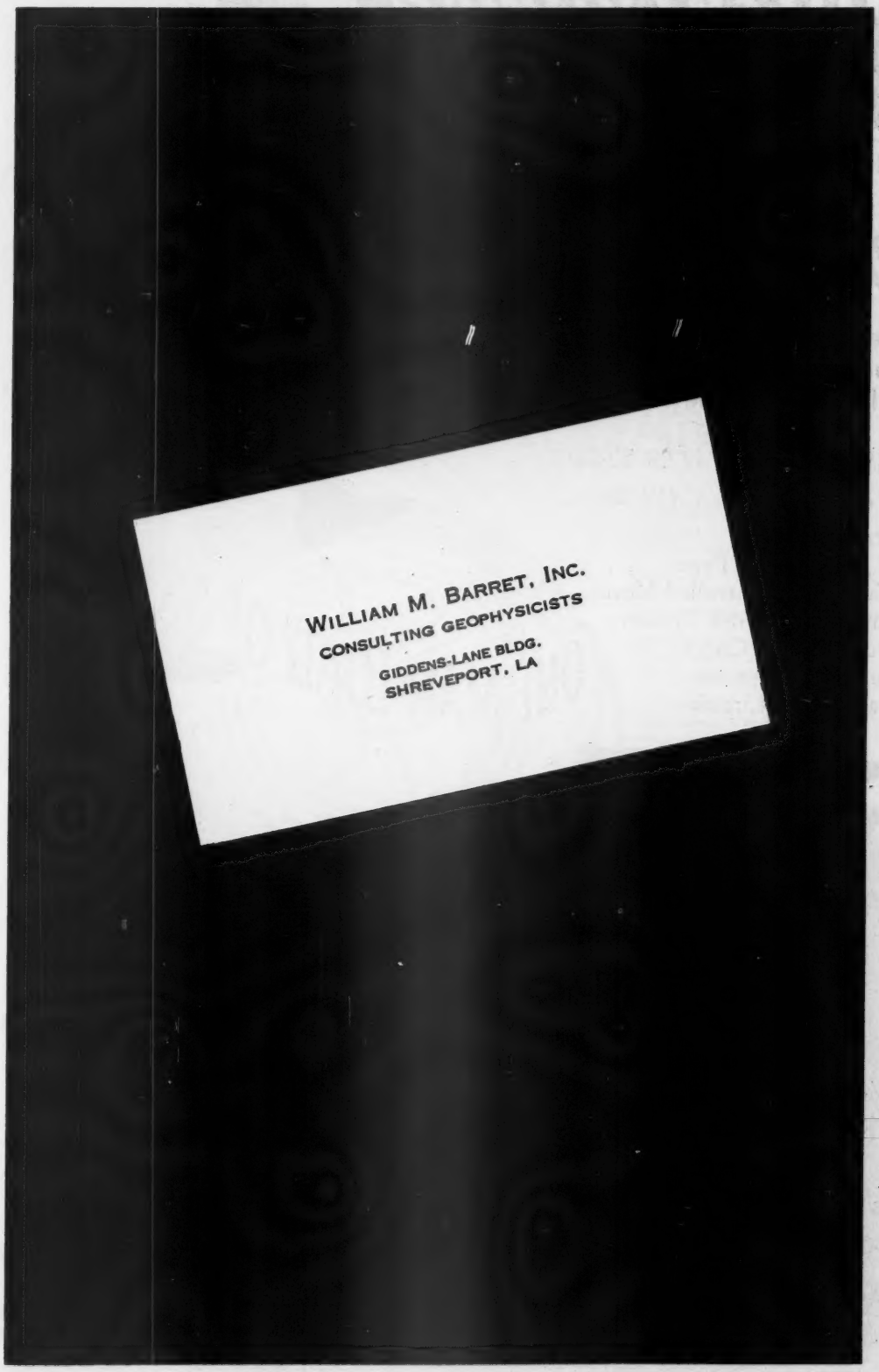

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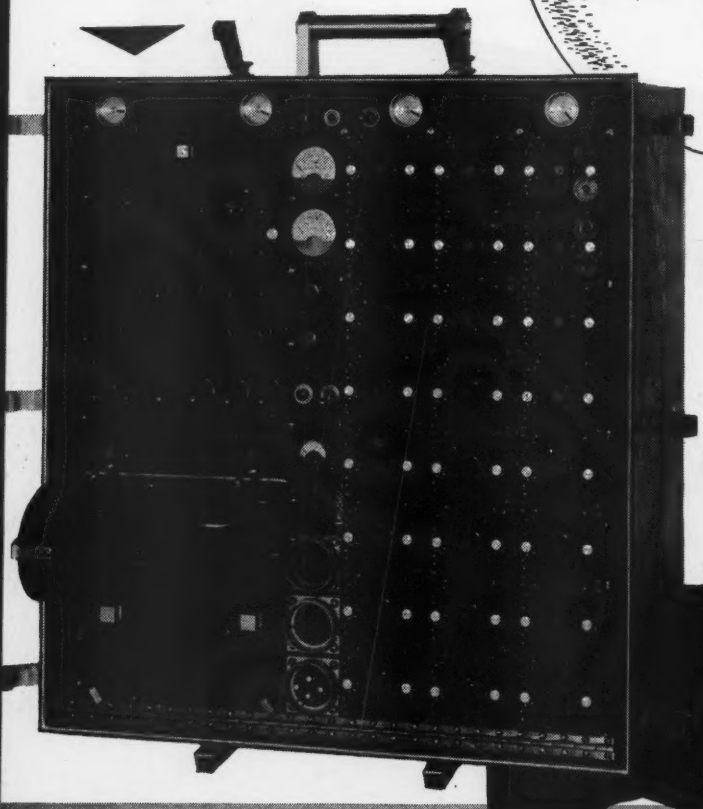

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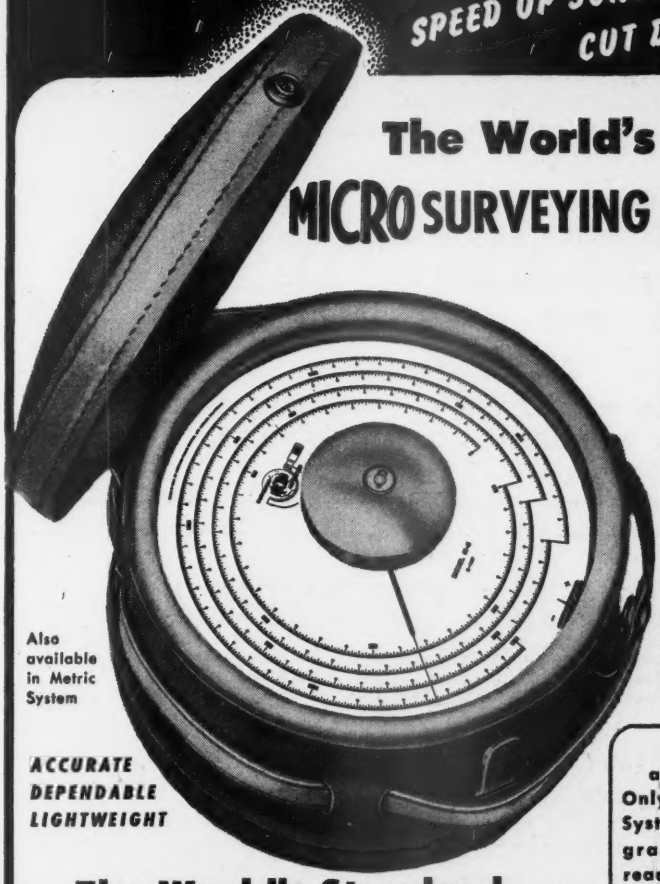

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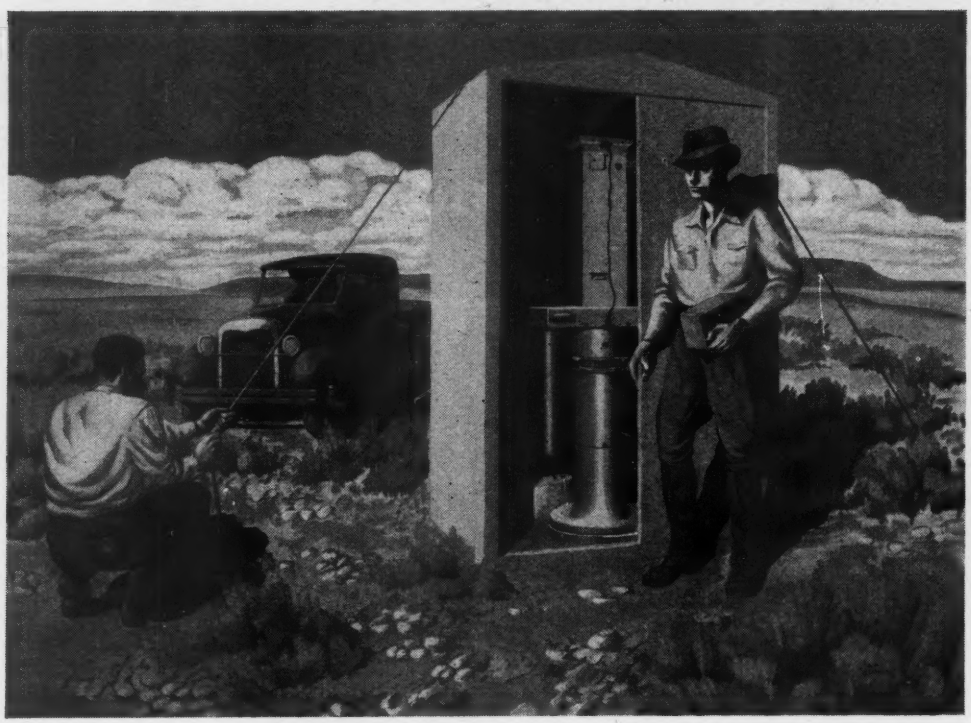

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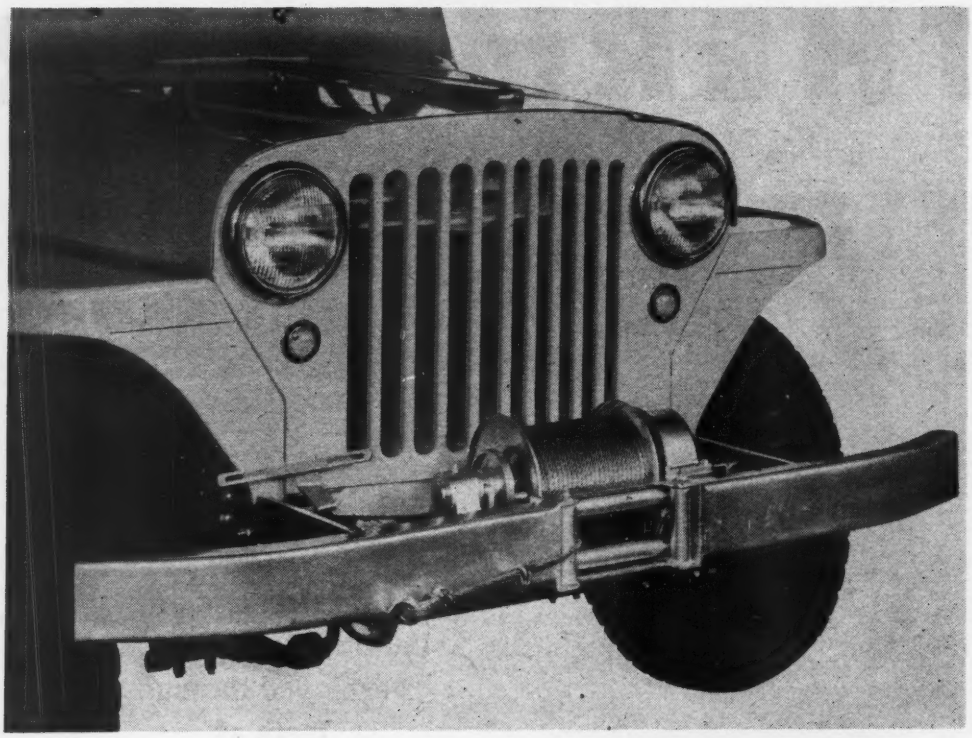

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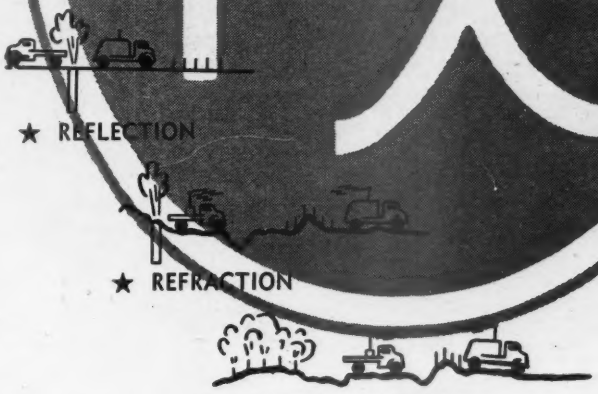

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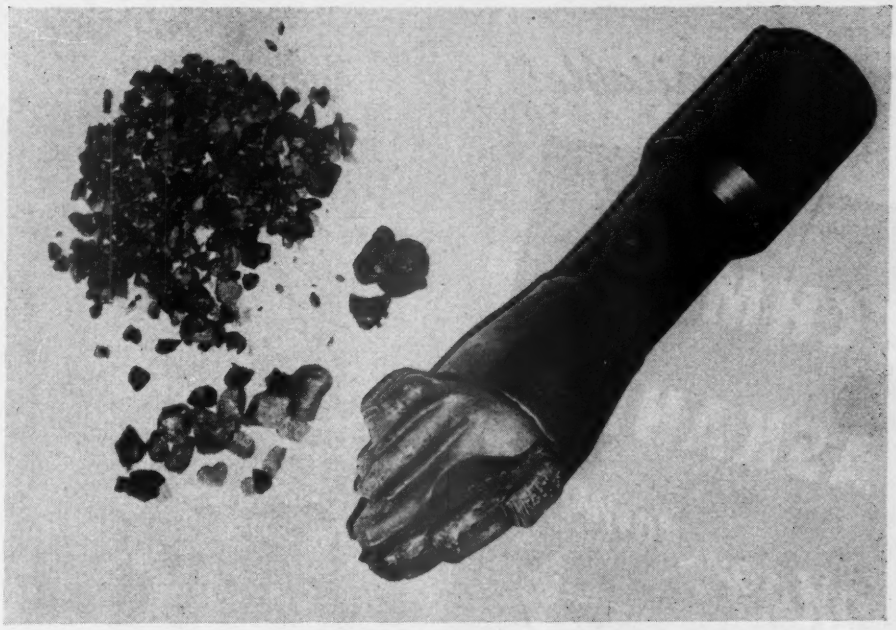

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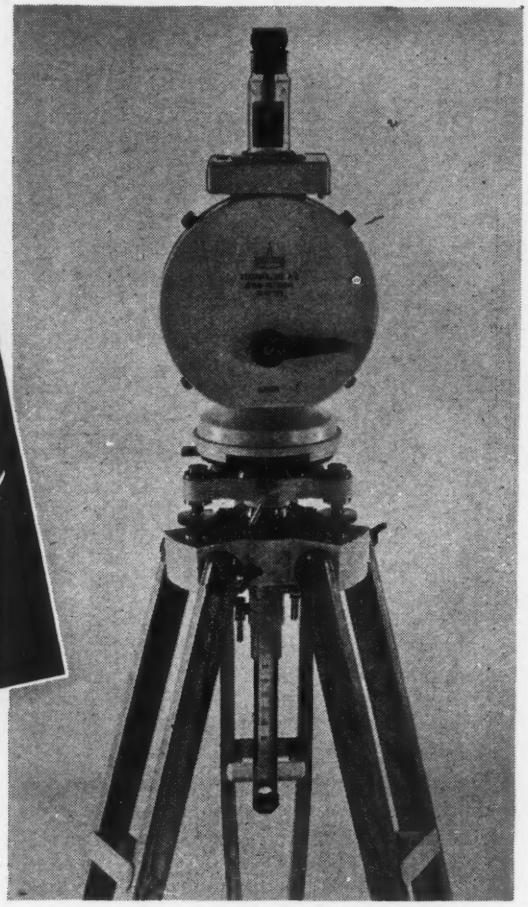

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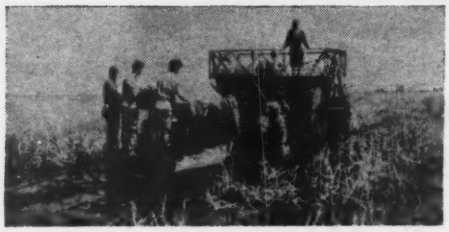

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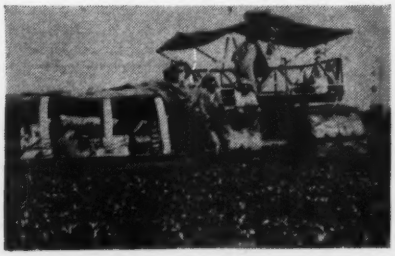

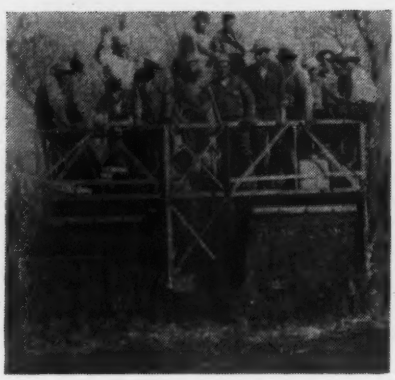

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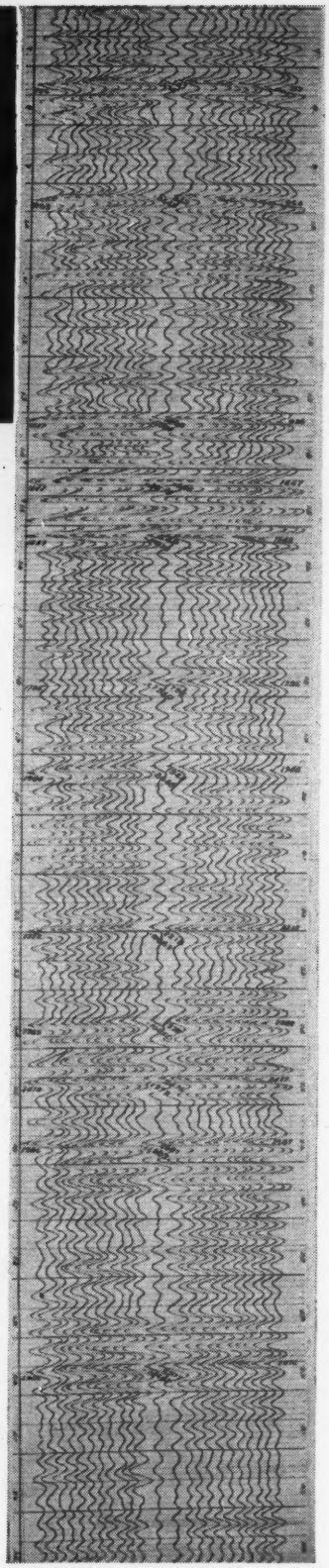

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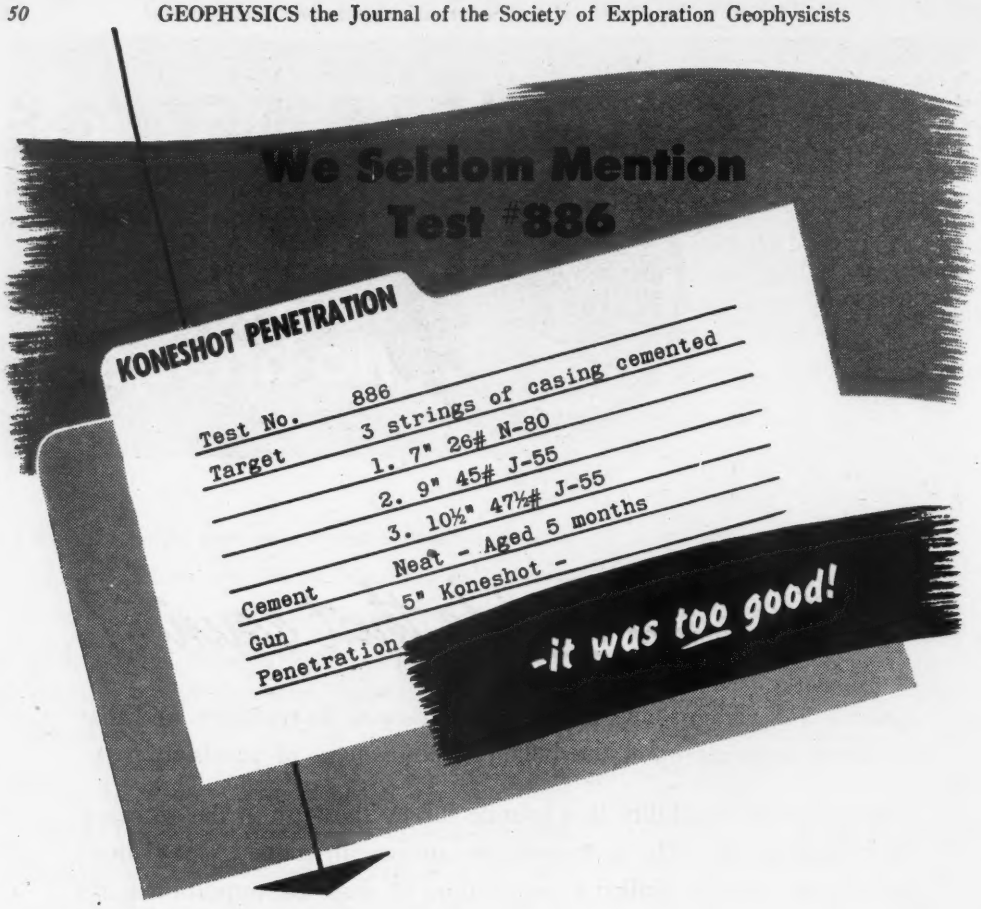

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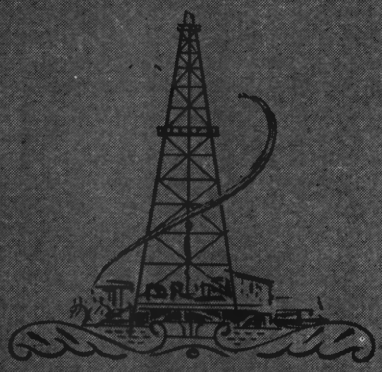

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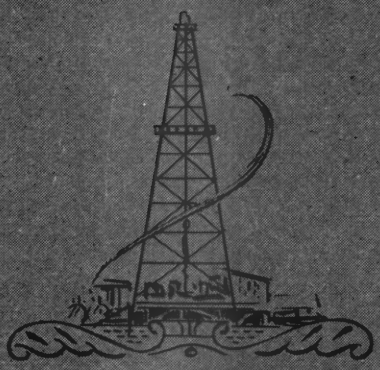

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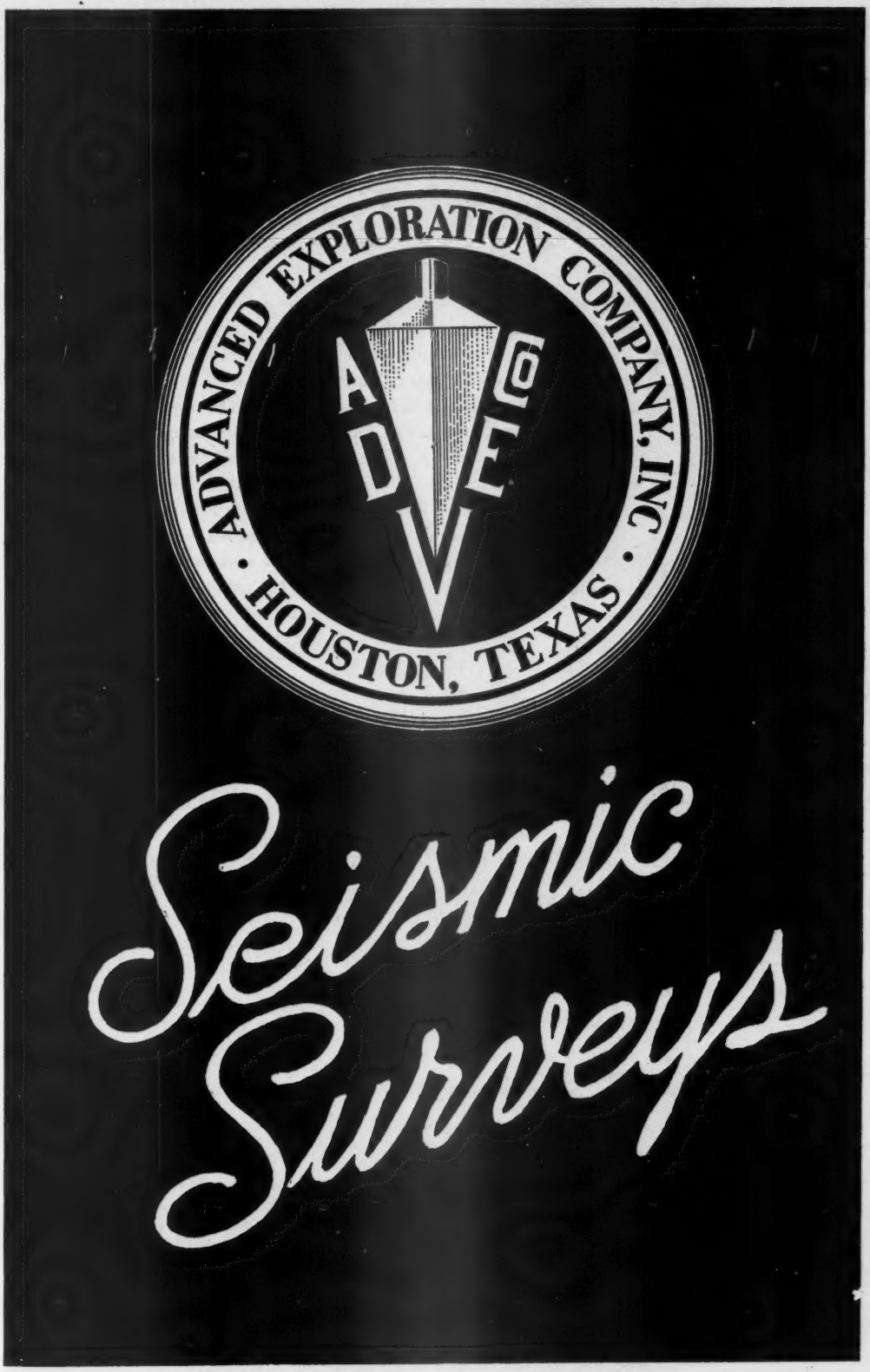
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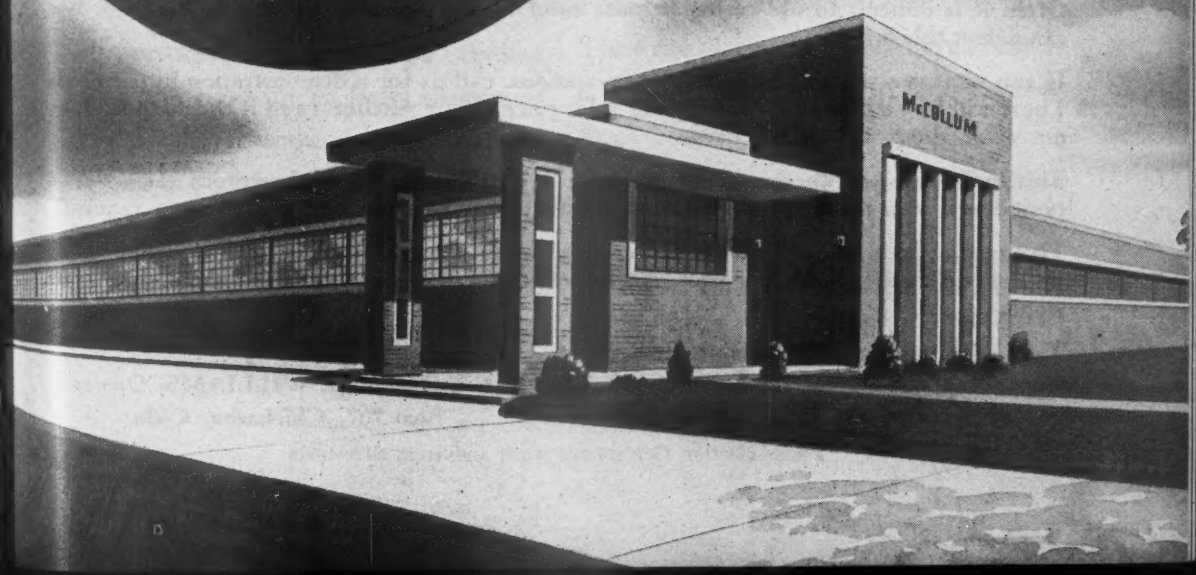

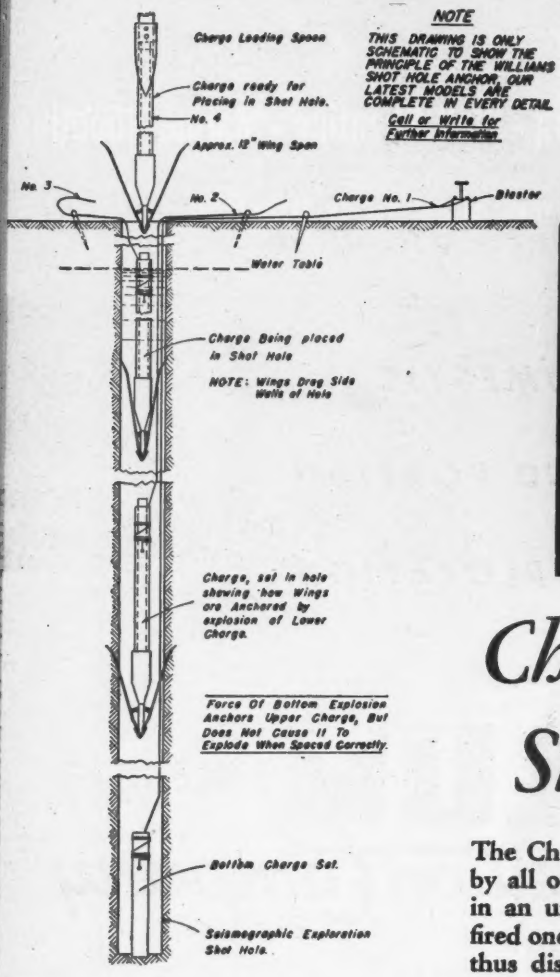
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Bottom Charge Set.
Seismographic Exploration Shot Hole.

Patent Number 2,450,366

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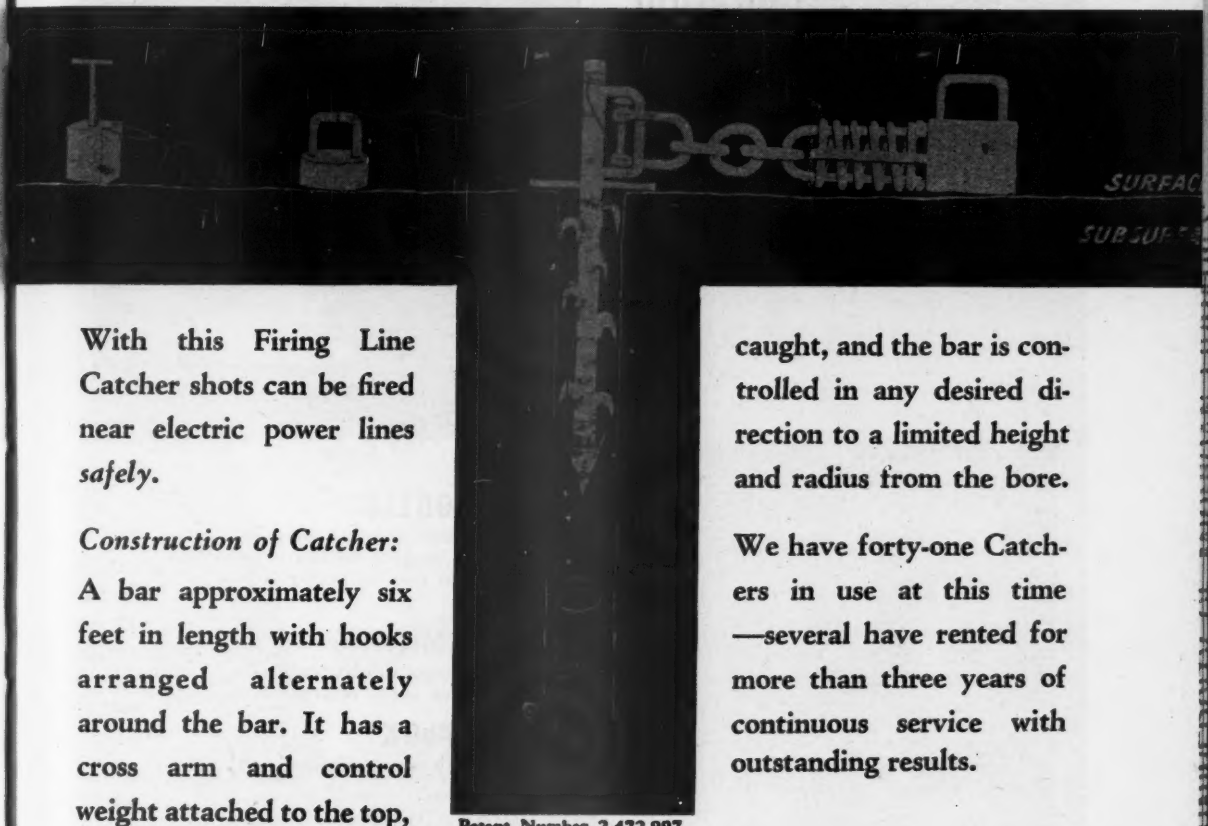

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A bar approximately six feet in length with hooks arranged alternately around the bar. It has a cross arm and control weight attached to the top, and also a circuit breaking weight.

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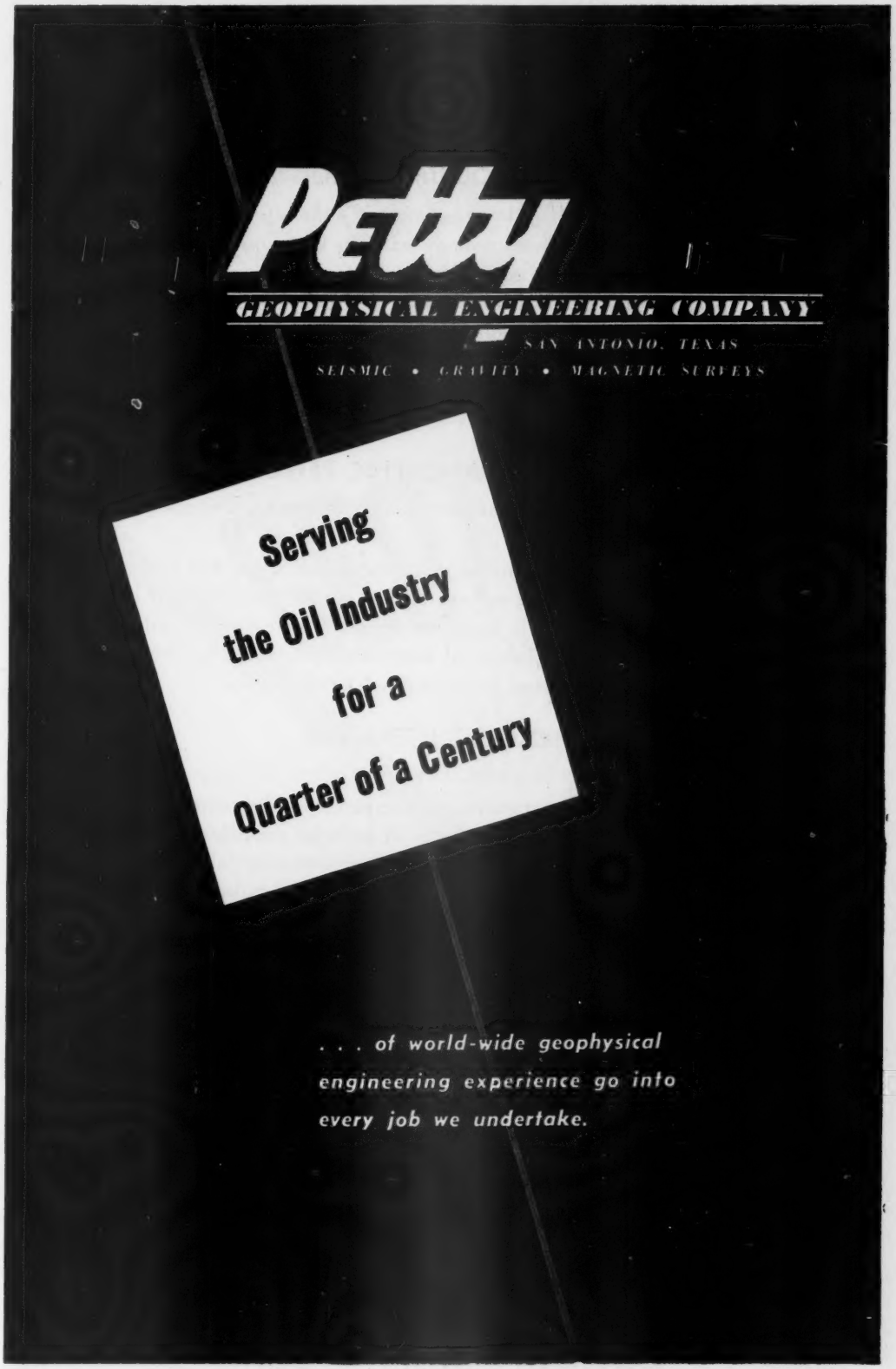
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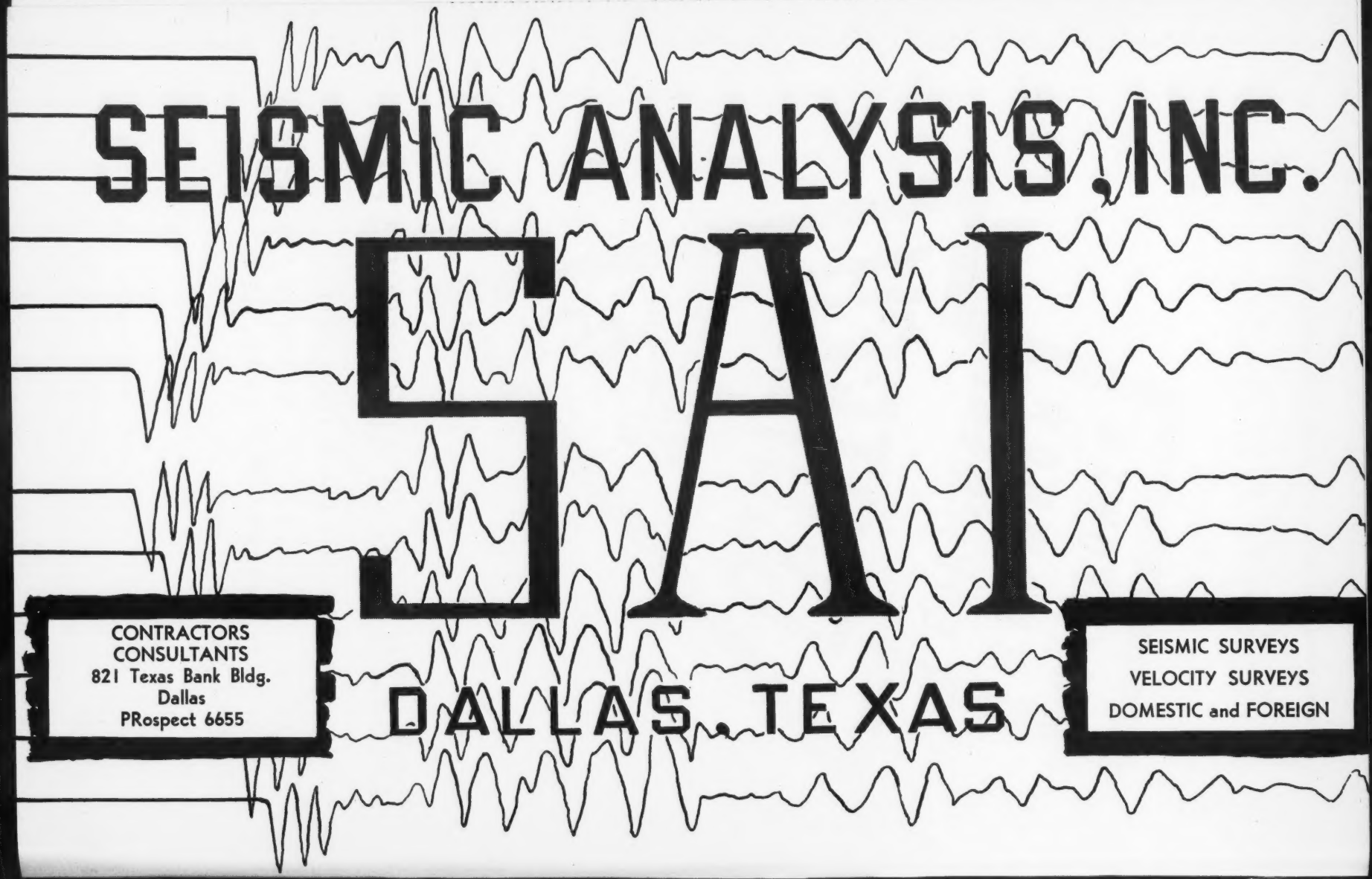
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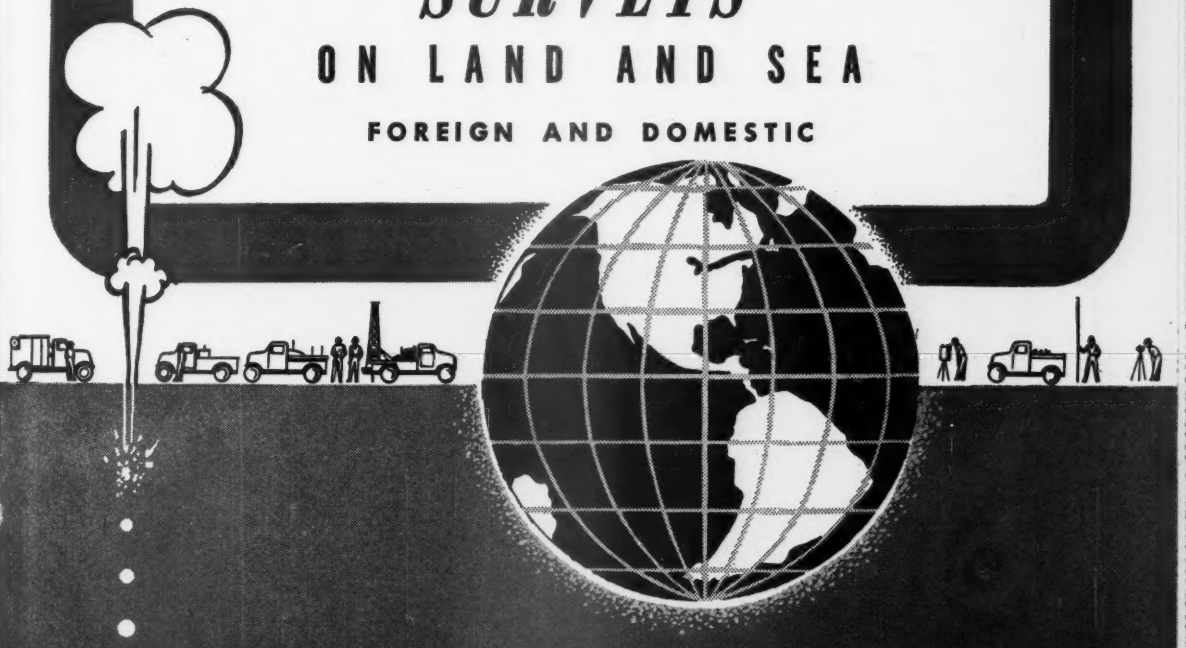

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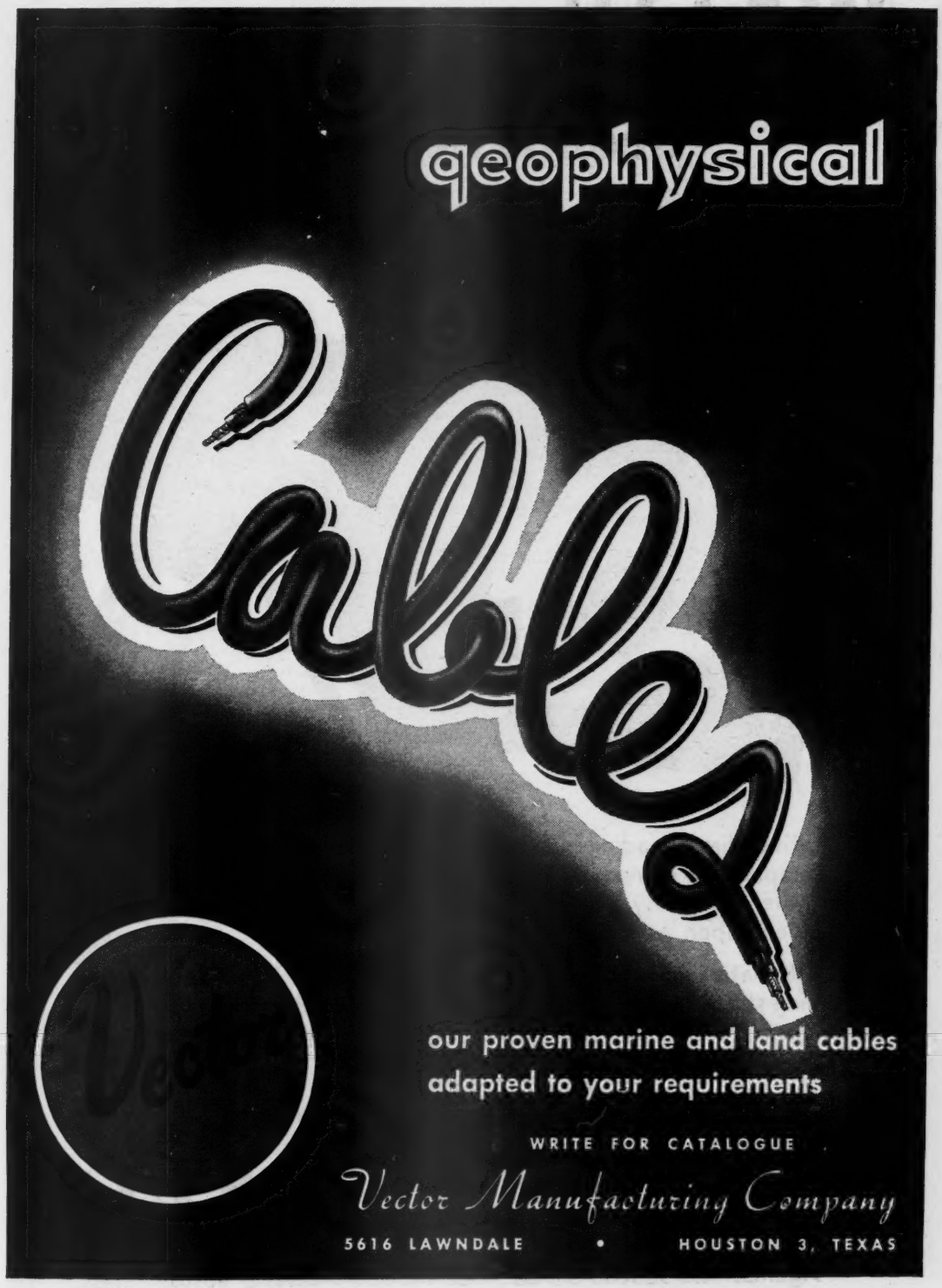
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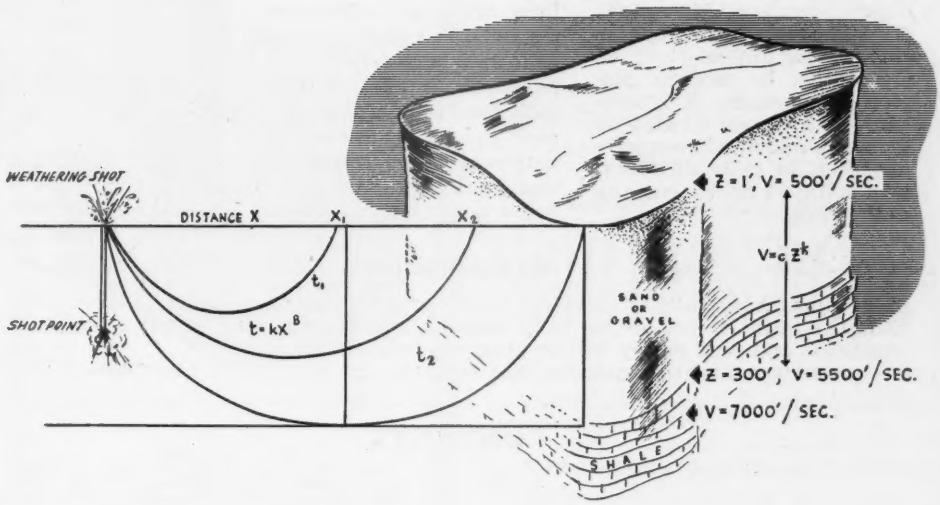

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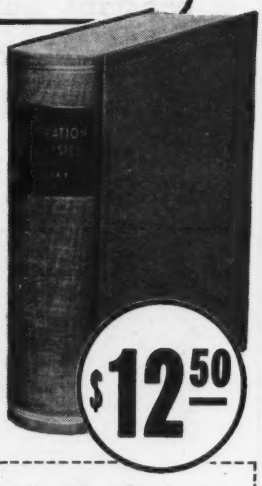

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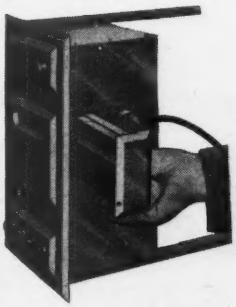

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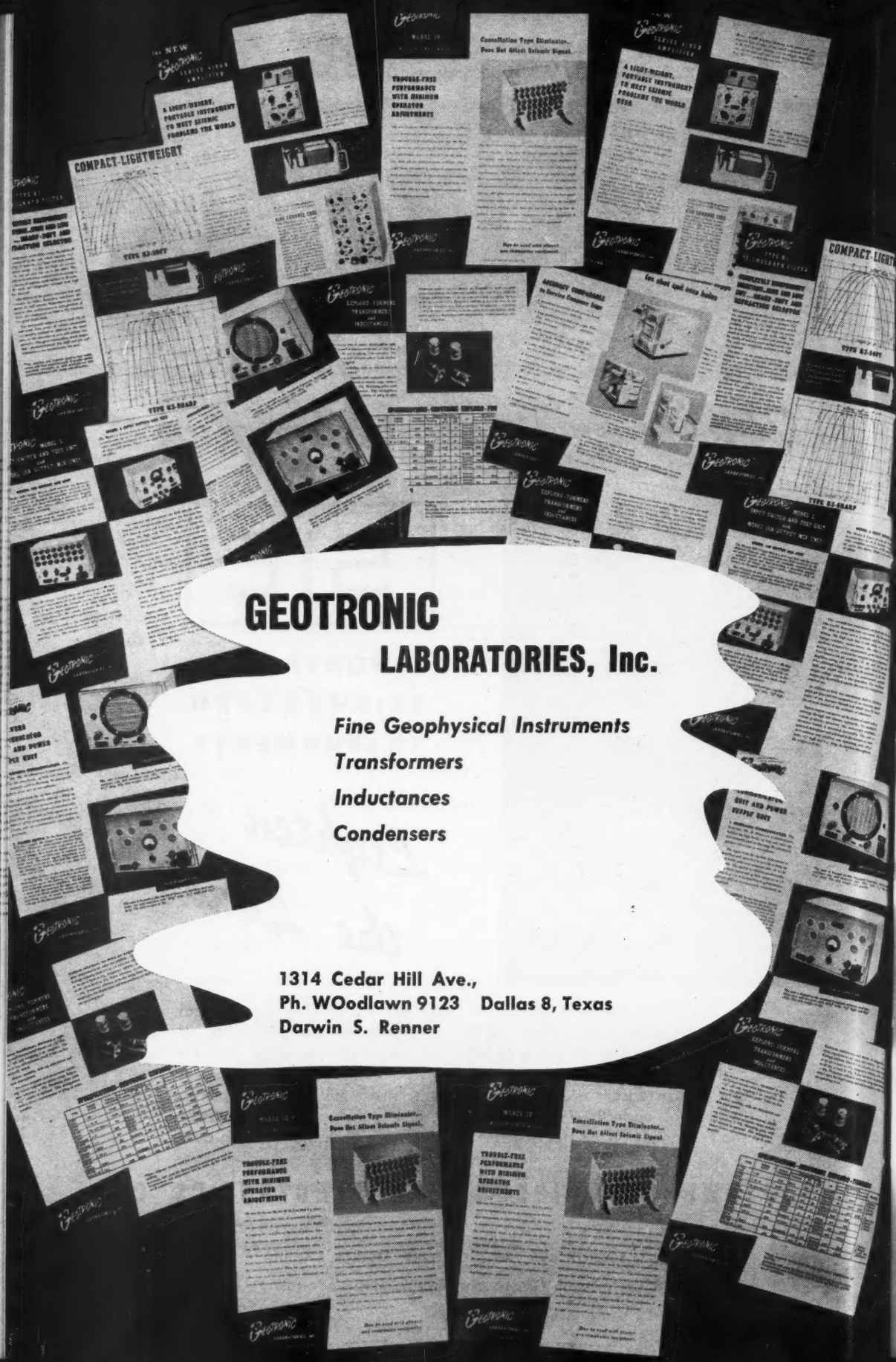
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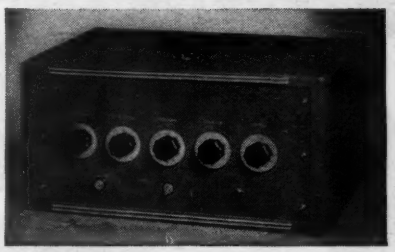

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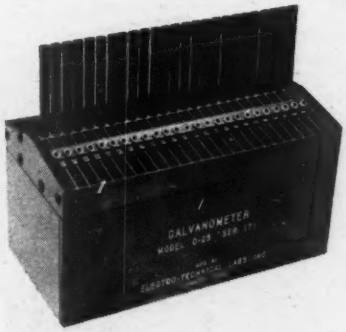

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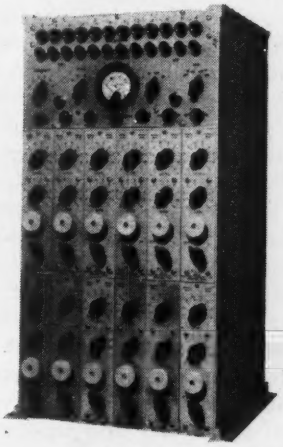

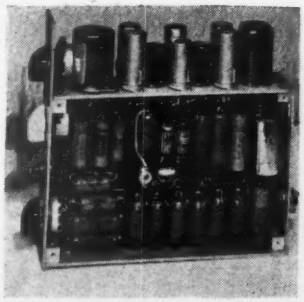

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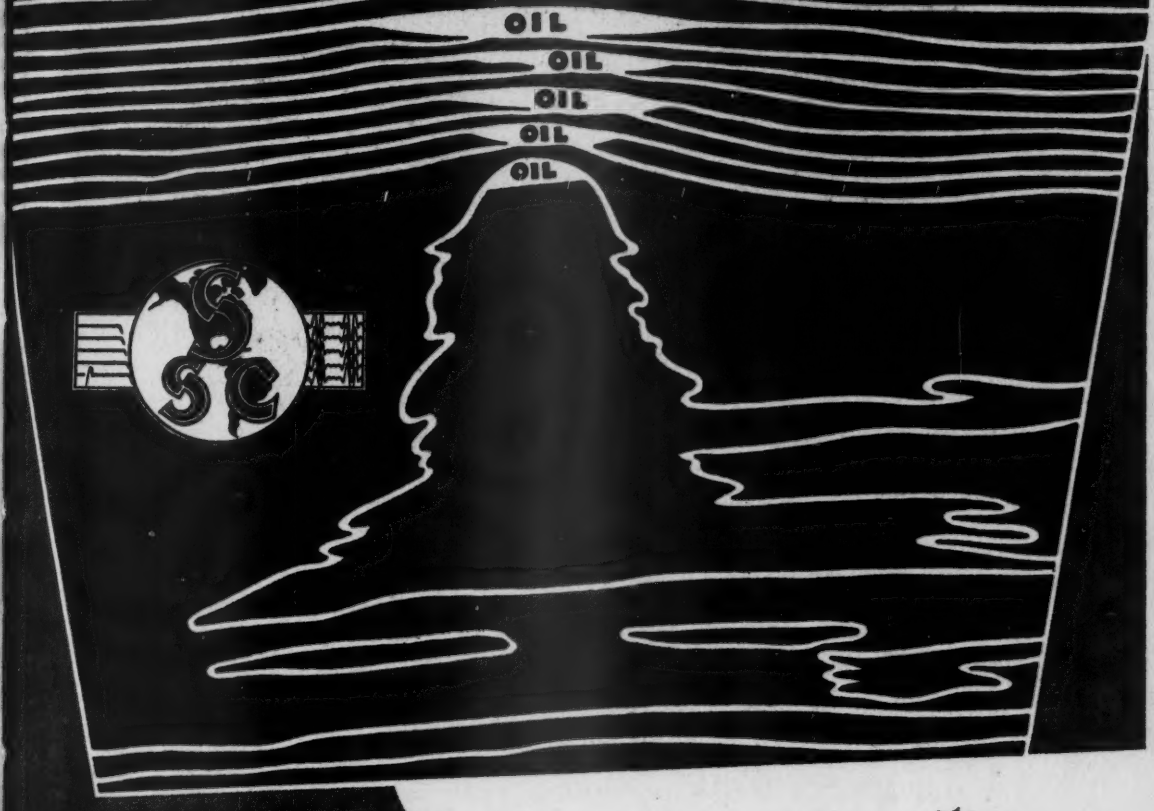
JU-1597

Are you looking for Reefs?



Texas) AREA REEFS

The above sketch is an idealized conception of the general geologic features.

These reefs are of the pinnacle type with somewhat unusual conditions often existing in the interval between the base of the reef proper and limestone resting on underlying dolomite. The illustration shows a discontinuity in reefing conditions on one side during its growth.

Limes and sands draped over the reef are usually oil bearing. The occurrence of oil in the flp of the reef only may not ultimately apply to all reefs in this area.

Shallow draping and reef presence combine to aid in oil exploration in this general area. That is, a shallow drape structure may lead to reef discovery, or a known reef body may lead to a shallow discovery in the overlying draped beds.

SSC Recommends the Following Approach for Seismic Reef Exploration.

NO. 2 HIGHEST RECORD QUALITY

The sedimentary complications that abut and surround organic reefs usually produce similarly complex seismic reflections. Controlled instrument and shooting tests at the beginning of a survey followed by continual supervisory checks during its progress will determine and maintain the instrumental characteristics and shooting procedure required to record satisfactorily the desired energy. Through this approach, SSC obtains SUPERLATIVE RECORD QUALITY—A MUST for a successful reef exploration program.

(This is one of a series)

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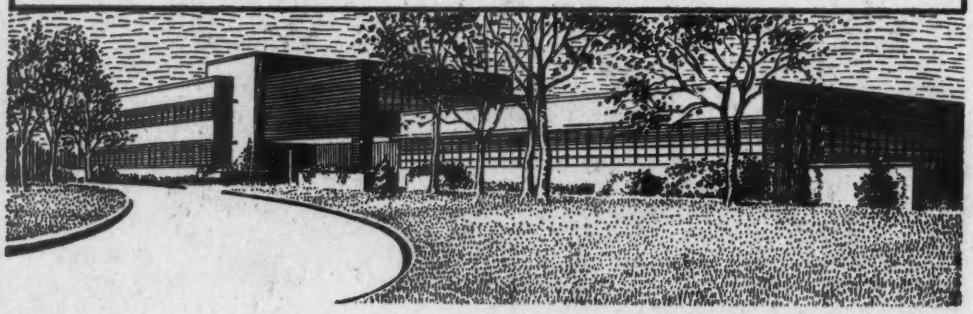
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